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(21) International Application Number: PCT/US92/07717 (22) International Filing Date: 11 September 1992 (11.09.92) (30) Priority data: 07/759,222 13 September 1991 (13.09.91) US (71) Applicant: BORON BIOLOGICALS, INC. [US/US]; 533 Pylon Drive, Raleigh, NC 27636-3489 (US). (72) Inventors: SPIELVOGEL, Bernard, F. ; 4009 Lehigh Court, Raleigh, NC 27609 (US). SOOD, Anup ; 5041 Gateway Drive, Durham, NC 27712 (US). HALL, Iris, H. ; 123 Weatherhill Pointe, Carrboro, NC 27510 (US). (74) Agent: HULTQUIST, Steven, J.; IP/TL, P.O. Box 14329, 100 Park Drive, Research Triangle Park, NC 27709 (US).		(81) Designated States: JP, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, SE). Published <i>With international search report.</i> <i>With amended claims and statement.</i>
(54) Title: METHOD OF COMBATting OSTEOPOROSIS AND OTHER DISEASE STATES IN MAMMALIAN SUBJECTS, UTILIZING ORGANIC BORON COMPOUNDS (57) Abstract <p>A method of combatting, e.g., preventing as well as treating, a disease state such as cystic fibrosis, neonatal hypoxemia, pulmonary hypertension, adult respiratory distress syndrome, psoriasis, spondyloarthritis, rheumatoid arthritis, gout, inflammatory bowel disease, myocardial infarctions, and/or osteoporosis in an animal subject, by administering to the animal subject an amount of an organic boron compound which is effective thereagainst. The organic boron compound usefully employed in the method of the invention include any suitable organic boron-containing compounds, such as Lewis base-boron adducts; a preferred class of organic boron compounds useful in such method includes boron analogs of α-amino acids, and the corresponding amides and esters of such amino acids. A method is also disclosed of inhibiting enzyme activity in <i>in vitro</i> or <i>in vivo</i> systems comprising administering to such system an enzyme-inhibiting amount of an organic boron compound. Further disclosed is a method of reducing hydroxyproline, calcium, and/or inorganic phosphorous in serum and/or urine of an animal subject, by administering to the animal subject an effective amount of an organic boron compound.</p>		

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-1-

"METHOD OF COMBATTING OSTEOPOROSIS AND OTHER DISEASE
STATES IN MAMMALIAN
SUBJECTS, UTILIZING ORGANIC BORON COMPOUNDS"

DESCRIPTION

Field of the Invention

The present invention relates to a method for preventing and/or treating osteoporosis and other disease states in animal subjects, utilizing organic boron compounds.

Description of the Related Art

The adult skeleton is composed of 80% cortical and 20% trabecular bone. Bone matrix is composed of 25% collagen, 65% inorganic material, and 10% non-cellular proteins (i.e., osteocalcin, silaoprotein, proteoglycans and osteonectin) and lipids. Osteoblasts synthesize and secrete Type 1 collagen and mucopolysaccharides to form the bone matrix which is laid down between the thin layers of osteoid. The layers are subsequently mineralized with 99% of the body's calcium found in the bone as a calcium phosphate complex with hydroxyapatite. Osteoblasts also synthesize and release Pg-E₂, osteocalcin, osteonectin, and collagenase. These cells have membrane receptors for PTH, VitD, and glucocorticosteroids.

Osteoclasts are multi-nucleated cells which reabsorb calcium from bone and cartilage. These cells may be derived from hemopoietic stem cells, i.e., mono-nucleated phagocytic cells. These cells lie on the bone surface (Howship's lacunae) and the surface becomes ruffled (motile microvilli). This area is sealed off from the neighboring cells. In these pockets, acid is produced which activates acidic hydrolytic enzymes and neutral proteases are released. Calcium is chelated by organic anions, e.g., citrate.

²

Osteoblasts release collagenase which removes protein from the surface of the bone, thus allowing the osteoclasts to attach. Collagenase cleaves the native helical molecule of collagen. The other proteolytic enzymes, e.g. neutral and acidic cathepsins, digest the protein further with the release of hydroxyproline to the extracellular compartment, which is an index of bone resorption. Hydroxyapatite protects collagen from denaturation. Collagenase and stromelysin are extracellular calcium dependent, zinc endoproteinases which hydrolyze collagen. Proteoglycan is thought to be a substrate for stromelysin (matrixin, proteoglycanase, transin, and MMP-3). These enzymes exist as zymogens or proenzymes. The proenzymes are activated by organomercurials, serine proteinases, oxidants and surfactants. The amino acid sequences of the metalloproteinases are known from the corresponding cDNA. The activity of the enzyme is inhibited by endogenous tissue inhibitors (TIMP). In humans a collagenase inhibitor has been identified in the alpha-2 macroglobulin fraction of plasma. Previous studies have shown that hydroxamates, thiol analogs, phosphorous-based derivatives, eriochrome, black T and gold inhibit collagenase, HFC activity.

Osteoporosis is generally associated with a reduced trabecular bone volume leading to increased risk of bone fractures. This process is probably due to a metabolic imbalance between the rates of new bone formation and bone resorption. Osteoporosis can be divided into two classes: (1) type I or post-menopausal, which is related to reductions in estrogen content and affects primarily trabecular bone, and (2) type II or senile, which is related to reduced calcium absorption and affects primarily cortical bone.

Bone resorption can be divided into two processes which are probably being carried out concurrently. Phase I involves the inorganic metabolism conducted principally by osteoclasts,

macrophages, monocytes, PMNs, and fibroblasts. This process is regulated by PTH, Pg-E₂, and cAMP which activate lysosomal hydrolytic enzymes and causes solubilization of the minerals in the bone, releasing calcium to the blood. Phase II involves organic metabolism where there is proteolytic destruction of the bone matrix collagen, releasing hydroxyproline to the blood. This process is initiated by the release of collagenase and cathepsin D from osteoblasts at the bone surface. The cellular enzymes belong to the metalloproteinase group of proteolytic enzymes which usually function at neutral pH. PTH binds to membrane receptors on osteoblasts, pre-osteoblasts and osteocytes, which activates the release of calcium from the dense bone, probably due to the activation of lysosomal enzymes, e.g., cathepsins, cAMP, interleukin-1, or prostaglandins.

In the elderly population there is a decrease of estrogen, progesterone, testosterone and vitamin D3 levels with age. With advanced age there is a reduction of calcitonin which severely reduces calcium absorption from the gut. There is a positive correlation between the extracellular reduction of these physiological parameters and with osteoporosis. Other factors are: smoking, lack of exercise, sunlight, and disease states like myeloma, skeletal metastasis, gastric surgery, anti-convulsant therapy, male hypogonadism, thyrotoxicosis, amenorrhea, anorexia nervosa, hyperprolactinemia, diabetes mellitus, immobilization, osteogenic imperfecta, and homocystinuria.

A number of agents have been noted to attenuate loss of bone mass in elderly humans or to accelerate bone growth in the young, such as estrogens, insulin, fluorides, anabolic steroids, calcitonin, growth hormone, fibroblast growth factor, transforming growth factor, epidermoid growth factor, bone morphogenic protein (osteogenin), diphosphates, and oral calcium supplements, with varying degrees of success. Most evidence today indicates that massive intakes of calcium (1500-2000

mg/day) orally does not prevent⁴ bone loss in post-menopausal women. It is not clear what the mechanism of action of estrogen is in blocking bone resorption. Estrogen therapy increases calcitonin in menopausal women which activates the metabolite of Vit-D3 for calcium absorption from the gut. There may be more receptors in the gut for the absorption of calcium in the presence of estrogen and there is an increase in calcium binding protein. Progesterone probably facilitates calcium flux into bone. Calcitonin acts directly on osteoclasts via cAMP to inhibit bone resorption.

Bone mass is decreased by treatment with the following drugs over a long period of time: glucocorticoids, thyroxine, heparin, cytotoxic drugs, retinoids [vit A], phorbol esters, Pg-E's, interleukin-1, endotoxins and parathyroid hormone (PTH). Apparently PTH stimulates production and release of cAMP and prostaglandin synthesis which is coupled with the release of collagenase. This causes the osteoblasts to become flattened and fibroblastic in shape. They release chemical substances, Pg-E₂, which attract osteoclasts to the surface of the bone. Pg-E₂ triggers the release of osteoclasts activating factor. At the surface there is local production of acids and carbonic anhydrase II, an isoenzyme. Inhibition of these metabolic processes also slows the bone resorption process.

At this stage there is an influx of other types of cells, e.g., macrophages, fibroblasts and monocytes which can continue the resorption process. Certain mechanisms in the movement of calcium from blood to bone are known. The metabolite of vitamin D, 1,25(OH)₂Vit-D₃, induces calcium transport by binding to a specific cytosol/nuclear receptor and forming a complex. This complex binds to chromatin DNA increasing template activity and initiating the synthesis of the calcium binding protein. Corticosteroids are known to suppress prostaglandin synthesis and reduce the levels of osteocalcin (Gla protein, or BGP). This protein stimulates osteoblastic activity.

5

There are data which suggest that corticosteroids modulate the number of receptors on osteoblasts for 1,25(OH)₂Vit-D₃, as well as alkaline phosphatase and collagen synthesis. Sodium fluoride stimulates osteoblast function by recruiting an increased number of osteoblasts. There is evidence that fluorapatite crystals form which are more resistant to resorption. Bisphosphonates are inhibitors of crystallization and calcification of bone. Heparin increases the production of collagenase and enhances its release and activity. Thus there are numerous sites within the regulation of calcium metabolism and proteolytic enzymes where therapeutic agents may function.

Bone resorption appears to be blocked by sulfanilamide, acetazolamide, methazolamide, benzolamide, ethoxzolamide, flurbiprofen and boron. No doubt a number of these agents are inhibiting the carbonic anhydrase enzyme so that hydrogen ions are not generated to produce an acidic medium. Other agents like thiazides inhibit calcium excretion in the urine. Boron depletion depresses growth in chicks when inadequate amounts of cholecalciferol is in the diet. Boron treatment (3.23 mg/day) of postmenopausal women has been shown to result in higher plasma levels of calcium and serum 25-hydroxycholecalciferol and lower levels of calcitonin and osteocalcin. Recent work at the U.S. Department of Agriculture (Grand Forks, North Dakota) has shown that inorganic boron, e.g., boric acid or sodium borate, in the diet at 3 mg/day blocks the urinary excretion of calcium, magnesium and perhaps phosphorus. Boron supplements markedly elevate estrogen and testosterone levels and supposedly block the process of osteoporosis. Dietary boron is useful in cholecalciferol-deficient chicks to correct cartilage growth.

Unfortunately, the intake of boron in the form of boric acid, or boric acid salts, has a number of undesirable side effects. The intake of boric acid (at dosages of 250 mg/kg for

16 days) has been found to cause severe degeneration of the testes with giant cell formation, pyknosis and exfoliation. Further, such intake of boric acid causes an increase in alkaline phosphatases in tissues, hepatic glycogen content, and maintenance of body fat. Nausea, vomiting, diarrhea, dermatitis, depressed growth, and lethargy occur in adults treated with boron as a trace element, in inorganic forms. Further, the metabolization of boron from such inorganic boron compounds is relatively inefficient. Finally, the marked elevation in estrogen and testosterone levels is associated with undesirable side effects in some instances, including mood disorders, water retention, Na^+ retention, thromboembolism, endometrial hyperplasia, cholestatic jaundice, headaches, gastrointestinal distress, virilization, and carcinoma of the biliary tract.

Accordingly, it would be a significant advance in the art to provide a method of combatting osteoporosis, which is not subject to the aforementioned deficiencies associated with boric acid and boric acid salts.

It would be particularly desirable to provide a method of combatting osteoporosis, which is bioactive via a non-estrogenic mechanism.

Accordingly, it is an object of the present invention to provide an improved method of combatting osteoporosis, which is free of the aforementioned deficiencies.

It is another object of the present invention to provide a method of combatting osteoporosis utilizing boron in a form taken up by cells more effectively than boric acid or borate salts, and which combats osteoporosis by different mechanisms than the boric acid and boric acid salt compounds used for such purpose in the prior art.

Other objects and advantages⁷ of the present invention will be more fully apparent from the ensuing disclosure and appended claims.

SUMMARY OF THE INVENTION

The present invention relates in one aspect to a method of combatting (e.g., preventing as well as treating) osteoporosis in an animal, e.g., mammalian subject, comprising administering to the animal subject an amount of an organic boron compound which is effective against such osteoporosis.

The organic boron compounds usefully employed in the broad practice of the present invention may include any suitable organic boron-containing compounds, such as Lewis base-boron adducts or any other boron-containing organic compounds which are effective to combat osteoporosis, as a preventative thereagainst, or as a treatment agent to ameliorate or reverse osteoporosis.

The organic boron compounds employed in the practice of the present invention may for example comprise at least one organic boron compound selected from the following classes:

Class 1: organic boron compounds of the formula:



wherein:

X is N or P;

R₁, R₂, R₃ are independently selected from H, C₁-C₂₀ linear or branched alkyl, alkoxy, alkylaryl, aryl, and substituted aryl, or R₁, R₂, and R₃ together with X form a heterocyclic ring structure, with the proviso that when X=N, R₁, R₂ and R₃ are not alkoxy;

⁸
 R₄ and R₅ are independently selected from H, C₁-C₂₀ linear or branched alkyl, aryl, alkylaryl, and substituted aryl;

R₆ is H, C₁-C₂₀ linear or branched alkyl, aryl, alkylaryl, substituted aryl, CN, COOH, COOM, COOR₇, CONHR₇, CONHOH, COAA, or

R₄, R₅, and R₆ together with B form a heterocyclic ring structure;

where:

M is Li, Na, K, or ammonium ion;

R₇ is H, C₁-C₁₀ alkyl, substituted alkyl, aryl, or substituted aryl; and

AA is NHCH(R₈)COOR₉ or NHCH(R₈)CONHR₉

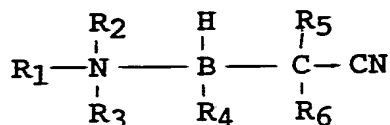
where R₈ is selected from the side chain of common amino acids and R₉ is H, or C₁-C₅ alkyl.

Class 2: organic boron compounds of the formula:



wherein: R₁, R₂, R₃, R₄ and X are same as above, and R₅ is CN.

Class 3: organic boron compounds of the formula:



wherein:

R₁, R₂ and R₃ are same as in Class 1;

R₄ is H, C₁-C₁₀ linear or branched alkyl, alkylaryl, or aryl; and

^a
R₅ and R₆ are independently selected from H, C₁-C₁₀ alkyl, alkylaryl, aryl, or substituted aryl.

Class 4: organic boron compounds of the formula:



wherein:

R₁ is C₁-C₁₀ linear or branched alkyl, alkylaryl, or aryl;

R₂, R₃ are independently selected from H, and C₁-C₁₀ linear or branched alkyl;

R₄ is H, C₁-C₁₀ linear or branched alkyl, alkylaryl, or aryl;

R₅ is CN, COOH, CONHR₆, COOR₆, wherein R₆ is same as R₇ in Class 1.

Class 5: organic boron compounds of the formula:



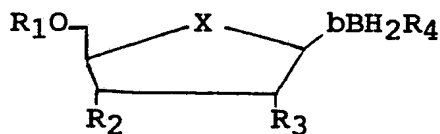
wherein:

X is O or S;

R₁, R₂, R₃ are independently selected from H, C₁-C₁₀ alkyl, alkylaryl, and aryl;

R₄ is NMe₂ or R₅, wherein R₅ is C₁-C₁₀ linear or branched alkyl, alkylaryl, aryl, or substituted aryl.

Class 6: organic boron compounds of the formula:



wherein:

X is C or O;

R₁ is H or a suitable protecting group, preferably

trialkylsilyl, benzoyl, or acetyl;¹⁰

R₂ is H or OH;

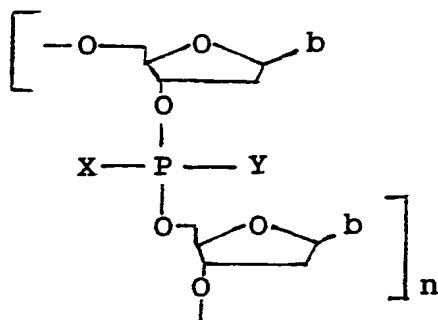
R₃ is H or OH;

b represents a nucleoside base, preferably with the BH₂R₄ group is bonded to a base nitrogen atom of the nucleoside base;

R₄ is CN, COOH, COOR₅, or CONHR₅, wherein R₅ is H, C₁-C₁₀ alkyl,

alkylaryl, aryl, or substituted aryl.

Class 7: organic boron compounds of the formula:



wherein:

n = 1-50, preferably 1-40, and most preferably 1-25;

b is a nucleoside base;

X is O, or OR (where R = CH₃, CH₂CH₂CN, or CH₂CH₃); and

Y is BH₃, BH₂CN, BH₂COOH, BH₂COOR₁, or BH₂CONHR,

wherein R₁ is H, or C₁-C₅ alkyl.

Class 8: metal complexes of amine-cyanoboranes and amine-carboxyboranes.

A preferred class of organic boron compounds having utility in combatting osteoporosis in the broad scope of the present invention are the organic boron compounds which (1) effect

inhibition of enzymes which are directly or indirectly involved in mediating osteoporosis, such as trypsin, collagenase, 5'-lipoxygenase, cyclooxygenase, elastase, etc., and (2) preferably also inhibit prostaglandin synthetase activity. These respective enzymes (trypsin, collagenase, elastase, prostaglandin synthetase, etc.) appear to favor bone resorption and can therefore create a metabolic imbalance favoring the development and progression of osteoporosis.

A particularly preferred class of organic boron compounds useful in the practice of the present invention includes Class 1 compounds of the formula $R_1R_2R_3NB(H)R_4COOH$, which are boron analogs of α -amino acids, and are isoelectronic and isostructural with the α -amino acids. The α -carbon in such compounds is replaced by boron. Corresponding amides and esters of such α -amino acids may also be usefully employed in the practice of the invention.

The carboxyborane adducts of amines, and corresponding esters and amides, are boron analogs of the amino acids that affect bone formation and/or resorption. These adducts exhibit particularly useful activity for anti-osteoporosis applications.

In another aspect, the present invention relates to a method of inhibiting enzyme activity in an animal subject attributable to at least one enzyme selected from the group consisting of collagenase, prostaglandin synthetase, acidic phosphatase, aryl sulfatase, 5'-lipoxygenase, and prostaglandin cyclooxygenase, comprising administering to the animal subject an enzyme-inhibitingly effective amount of an organic boron compound effective against such at least one enzyme.

In a further aspect, the present invention relates to a method of combatting in an animal subject a disease state selected from the group consisting of osteoporosis, cystic fibrosis, neonatal hypoxemia, pulmonary hypertension, adult

respiratory distress syndrome,¹² psoriasis, spondyloarthritis, rheumatoid arthritis, gout, inflammatory bowel disease, myocardial infarctions, and combinations thereof, comprising administering to the animal subject a disease-combatting amount of an organic boron compound effective for combatting such disease state.

As used herein, the term "compound", in reference to organic boron compounds usefully employed in the practice of invention, is intended to be broadly construed to include compounds per se, as well as adducts, complexes, etc., which contain (1) boron in a therapeutic and bioavailable form, and (2) an organic moiety or moieties. Such "compounds" may be covalently, ionically, and/or otherwise associatively bonded, as regards the constituents thereof.

Other aspects and features of the invention will be more fully apparent from the ensuing disclosure and appended claims.

DETAILED DESCRIPTION OF THE INVENTION, AND PREFERRED EMBODIMENTS THEREOF

The present invention is based on the surprising and unexpected discovery that organic boron compounds may be employed (1) to combat osteoporosis as well as other disease states, e.g., cystic fibrosis, neonatal hypoxemia, pulmonary hypertension, adult respiratory distress syndrome, psoriasis, spondyloarthritis, rheumatoid arthritis, gout, inflammatory bowel disease, and myocardial infarctions, and/or (2) to inhibit enzyme activity of enzymes such as collagenase, aryl sulfatase, 5'-lipxygenase, prostaglandin cyclooxygenase, and combinations thereof, when effective amounts of organic boron compounds are administered to an animal subject, e.g., mammalian subject.

Organic boron compounds have been found to be taken up by cells far more effectively than inorganic boron compounds, e.g., boric acid or boron salts such as sodium borate. Further,

organic boron compounds have been discovered to be usefully employed without stimulating excess production of hormones such as estrogen and testosterone, thereby avoiding side effects and deficiencies associated with inorganic boron compounds. In addition, the organic boron compounds are easier to deliver to the metabolically effective locus, and in many cases are also associated with therapeutic benefits not present when inorganic boron compounds are employed, e.g., anti-inflammatory, anti-tumor, and anti-hyperlipidemic benefits.

The pronounced benefits available from the use of organic boron compounds in accordance with the present invention are truly unexpected in view of the many and severe deficiencies attending the administration of inorganic boron compounds. Such deficiencies of administering inorganic boron compounds to animal subjects include (1) marked elevation of estrogen and testosterone levels, with accompanying increased risk of cancer and hypertension, (2) severe degeneration of the testes with giant cell formation, pyknosis, and exfoliation, (3) nausea, (4) vomiting, (5) diarrhea, (6) dermatitis, (7) depressed growth, and (8) lethargy. Based on these substantial and undesired direct effects and side effects, as associated with administration of boron to animal subjects in inorganic forms, e.g., as boric acid or boric acid salts, it would be expected that organic boron compounds would effect the same deleterious results. This, fortunately and suprisingly, has not been the case.

The organic boron compounds which may be employed in the broad practice of the present invention include any suitable boron-containing organic compounds, preferably Lewis base-boron adducts.

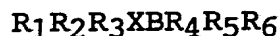
Organic boron compounds which have potential utility in the practice of the present invention include, but are not limited to: the amine-borane compounds disclosed in U.S. Patent Nos. 4,312,989 and 4,368,194; the ammonia-cyanoborane, sodium iodide

14

complexes disclosed in U.S. Patent 4,209,510; the carboxyborane compounds described in U.S. Patent 4,550,186; the amine carbamoylborane adducts described in U.S. Patent 4,587,359; the amine-carboxyborane compounds described in U.S. Patent 4,855,493; the boron analogs of amino acids described in U.S. Patent 4,647,555; the boron dipeptide compounds disclosed in U.S. Patent 4,977,268; the amine-alkylborane derivatives disclosed in U.S. Application Serial No. 364,650 filed June 9, 1989; the phosphite-borane compounds disclosed in U.S. Patent Application No. 07/701,682 filed May 10, 1991; organic boron compounds described in "Anti-Inflammatory Activity of Amine Cyanoboranes, Amine Carboxyboranes, and Related Compounds" Hall, I. H. et al, J. Pharm. Sci., Vol. 69, No. 9, September, 1980, pp. 1025-1029; and organic boron compounds disclosed in "Organoborane Chemistry", by Thomas Onak, Academic Press, New York, NY, 1975.

By way of illustration, the organic boron compounds potentially usefully employed in the broad practice of the invention may include boron-containing organic compounds selected from the following classes:

Class 1: organic boron compounds of the formula:



wherein:

X is N or P;

R₁, R₂, R₃ are independently selected from H, C₁-C₂₀ linear or branched alkyl, alkoxy, alkylaryl, aryl, and substituted aryl, or R₁, R₂, and R₃ together with X form a heterocyclic ring structure, with the proviso that when X=N, R₁, R₂ and R₃ are not alkoxy;

¹⁵
 R_4 and R_5 are independently selected from H, C_1 - C_{20} linear or branched alkyl, aryl, alkylaryl, and substituted aryl;

R_6 is H, C_1 - C_{20} linear or branched alkyl, aryl, alkylaryl, substituted aryl, CN, COOH, COOM, COOR₇, CONHR₇, CONHOH, COAA, or

R_4 , R_5 , and R_6 together with B form a heterocyclic ring structure;

where:

M is Li, Na, K, or ammonium ion;

R_7 is H, C_1 - C_{10} alkyl, substituted alkyl, aryl, or substituted aryl; and

AA is NHCH(R_8)COOR₉ or NHCH(R_8)CONHR₉

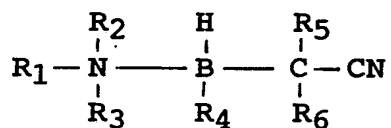
where R_8 is selected from the side chain of common amino acids and R_9 is H, or C_1 - C_5 alkyl.

Class 2: organic boron compounds of the formula:



wherein: R_1 , R_2 , R_3 , R_4 and X are same as above, and R_5 is CN.

Class 3: organic boron compounds of the formula:



wherein:

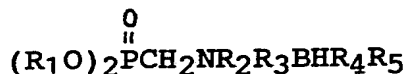
R_1 , R_2 and R_3 are same as in Class 1;

R_4 is H, C_1 - C_{10} linear or branched alkyl, alkylaryl, or aryl; and

16

R₅ and R₆ are independently selected from H, C₁-C₁₀ alkyl, alkylaryl, aryl, or substituted aryl.

Class 4: organic boron compounds of the formula:



wherein:

R₁ is C₁-C₁₀ linear or branched alkyl, alkylaryl, or aryl;

R₂, R₃ are independently selected from H, and C₁-C₁₀ linear or branched alkyl;

R₄ is H, C₁-C₁₀ linear or branched alkyl, alkylaryl, or aryl;

R₅ is CN, COOH, CONHR₆, COOR₆, wherein R₆ is same as R₇ in Class 1.

Class 5: organic boron compounds of the formula:



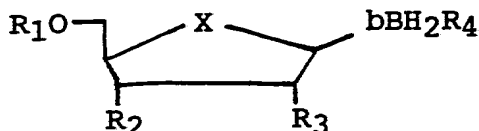
wherein:

X is O or S;

R₁, R₂, R₃ are independently selected from H, C₁-C₁₀ alkyl, alkylaryl, and aryl;

R₄ is NMe₂ or R₅, wherein R₅ is C₁-C₁₀ linear or branched alkyl, alkylaryl, aryl, or substituted aryl.

Class 6: organic boron compounds of the formula:



wherein:

X is C or O;

R₁ is H or a suitable protecting group, preferably trialkylsilyl, benzoyl, or acetyl;

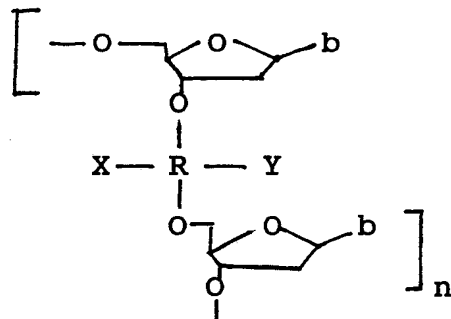
R_2 is H or OH;

R_3 is H or OH;

b represents a nucleoside base, wherein the BH_2R_4 group preferably is attached to a base nitrogen of the nucleoside base;

R_4 is CN, COOH, $COOR_5$, or $CONHR_5$, wherein R_5 is H, C_1 - C_{10} alkyl, alkylaryl, aryl, or substituted aryl.

Class 7: organic boron compounds of the formula:



wherein:

$n = 1$ -50, preferably 1-40, and most preferably 1-25;

b is a nucleoside base;

X is O, or OR (where $R = CH_3$, CH_2CH_2CN , or CH_2CH_3); and

Y is BH_3 , BH_2CN , BH_2COOH , BH_2COOR_1 , or BH_2CONHR ,

wherein R_1 is H, or C_1 - C_5 alkyl.

Class 8: metal complexes of amine-cyanoboranes and amine-carboxyboranes.

A particularly preferred class of organic boron compounds from the above-described classes comprises the Class 1 compounds, particularly those in which X is N, viz., the organic boron compounds of the formula:



These compounds include amine-carboxyboranes which are boron analogs of α -amino acids. As a result of their structural

similarity to such a-amino acids¹⁸, these compounds evidence a particularly high degree of biocompatibility (e.g., metabolic assimilatability, efficiency of metabolic uptake, and deliverability).

In general, the organic boron compounds employed in the method of the invention are readily bioassimilated in an effective and efficient manner, and are more easily deliverable in corporeal systems than are the inorganic boron compounds previously employed for osteoporosis treatment, viz., boric acid and boric acid salts. In addition, the organic boron compounds of the present invention combat osteoporosis and other disease states mentioned hereinabove, as well as effectively suppress certain enzymes which may be implicated in the causation and/or development of such disease states, via metabolic paths which do not effect excessive production of hormones such as estrogen and testosterone. As a result, the use of organic boron compounds in the method of the invention avoids the deficiencies of the prior art use of inorganic boron compounds.

While we do not wish to be bound by any theory or particular mechanism as regards the surprising and unexpected benefits of using organic boron compounds as anti-osteoporosis agents and/or agents for combatting other disease states, there is evidence that such efficacy is the result of inhibition of proteolytic enzymes and other enzymatic and proteinaceous species associated with the causative and developmental mechanisms of osteoporosis and the other mentioned disease states.

The organic boron compounds which are utilized in the method of the present invention may combat osteoporosis by opposing bone resorption processes which create an imbalance between bone formation and resorption. Such osteoporosis-combatting agents may effect such benefit by inhibiting either the inorganic phase resorption processes or organic resorption

processes. The inorganic phase of bone resorption includes cell-mediated solubilization of minerals such as Ca^{++} , as conducted by lysosomal acidic enzymes of osteoclasts, macrophages, monocytes, PMNs and fibroblasts. Such mineral solubilization process is stimulated by PTH, Pg-E_2 , and cAMP. The organic phase of bone resorption encompasses the proteolytic destruction of matrix collagen with hydroxyproline release from the bone. Such proteolytic destruction is conducted by collagenase of the osteoblasts, and by lysosomal proteases, such as cathepsin D, causing degradation of osteoid and lamina bone.

In this respect, the method of the present invention represents an effective approach to combatting osteoporosis and/or the other mentioned disease states, both from the standpoint of prophylactic efficacy of such method as well as its efficacy in respect of ameliorating or even reversing osteoporosis and/or such other disease states already in development.

Illustrative of organic boron compounds which may find utility in the broad practice of the present invention are the following specific boron-containing organic compounds:

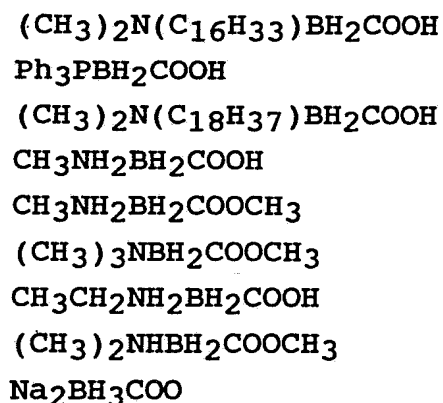
- (1) Trimethylamine-borane
- (2) t-Butylamine-borane
- (3) Dimethylamine-borane
- (4) Morpholine-borane
- (5) Diethylamine-borane
- (6) Pyridine-borane
- (7) Triphenylphosphine-borane
- (8) Ammonia-borane
- (9) Ammonia-cyanoborane
- (10) Methylamine-cyanoborane
- (11) Dimethylamine-cyanoborane
- (12) Trimethylamine-cyanoborane

20

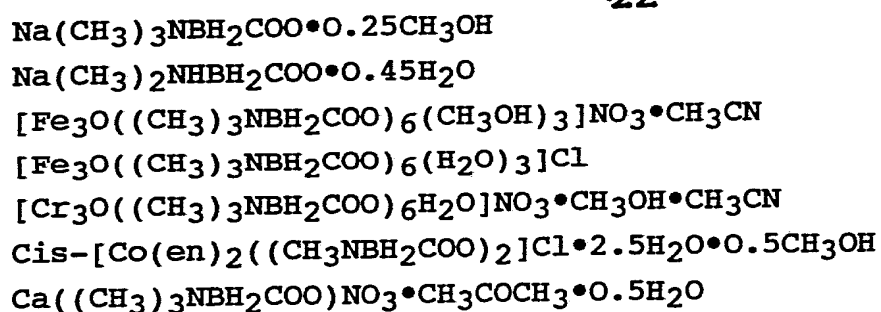
- (13) Triphenylphosphine-cyanoborane
- (14) Triethylphosphite-cyanoborane
- (15) 2'-Deoxycytidine-N3-cyanoborane
- (16) 2'-Deoxyadenosine-N1-cyanoborane
- (17) N-methylmorpholine-cyanoborane
- (18) Ethylenediamine-bis(cyanoborane)
- (19) N,N,N',N'-Tetramethylethylenediamine-bis(cyanoborane)
- (20) Morpholine-carboxyborane
- (21) Triphenylphosphine-carboxyborane
- (22) Trimethylamine-carboxyborane
- (23) Ammonia-carboxyborane
- (24) Triethylphosphite-carboxyborane
- (25) N,N-Dimethyloctadecylamine-carboxyborane
- (26) N,N-Dimethylhexadecylamine-carboxyborane
- (27) Trimethylamine-carboethoxyborane
- (28) Trimethylamine-carbomethoxyborane
- (29) Trimethylamine-carbobenzoxoyborane
- (30) Methylamine-carbomethoxyborane
- (31) Dimethylamine-carbomethoxyborane
- (32) Ammonia-carbomethoxyborane
- (33) N,N-Dimethylhexadecylamine-carbomethoxyborane
- (34) N,N-Dimethyloctadecylamine-carbomethoxyborane
- (35) Ammonia-N-ethylcarbamoyleborane
- (36) Methylamine-N-ethylcarbamoyleborane
- (37) Dimethylamine-N-ethylcarbamoyleborane
- (38) Trimethylamine-N-ethylcarbamoyleborane
- (39) Trimethylamine-N-propylcarbamoyleborane
- (40) Trimethylamine-N-phenylcarbamoyleborane
- (41) Trimethylamine-N-octylcarbamoyleborane
- (42) 2-(Acetoxy)ethyldimethylamine-borane
- (43) 2-(Thioacetoxy)ethyldimethylamine-borane
- (44) 2-(Hydroxy)ethyldimethylamine-borane
- (45) Diethyl((N,N-Dimethylamine)methyl)phosphonate-N-cyanoborane
- (46) Trimethylamine-methyldicyanoborane
- (47) Trimethylamine-isopropyldicyanoborane

- (48) Trimethylamine-boranecarbohydroxamic acid tetraphenylborate salt.
- (49) [(Trimethylamine-boryl)carbonyl]glycine methyl ester
- (50) [(Trimethylamine-boryl)carbonyl]phenylalanine methyl ester
- (51) [(Trimethylamine-boryl)carbonyl]tyrosine methyl ester
- (52) [(Trimethylamine-boryl)carbonyl]serine methyl ester
- (53) [(Trimethylamine-boryl)carbonyl]methionine methyl ester
- (54) [(Ammonia-boryl)carbonyl]valine methyl ester
- (55) [(Ammonia-boryl)carbonyl]isoleucine methyl ester
- (56) [(Ammonia-boryl)carbonyl]leucine amide
- (57) Pyridine-carboxyborane
- (58) N-Methylpyridine-carboxyborane
- (59) N-Cyanopyridine-carboxyborane
- (60) Trimethylamine-cyanomethylborane
- (61) Trimethylamine-2-cyanoisopropylborane
- (62) Trimethylamine-a-cyanobenzylborane
- (63) Trimethylamine-carboxyborane, sodium salt
- (64) Dimethylamine-carboxyborane, sodium salt

In general, carboxyborane adducts of Lewis bases (e.g., boron analogs of α -amino acids) and amide and ester derivatives thereof are a preferred class of organic boron compounds in the practice of the present invention, and metal complexes of such Lewis base-carboxyborane adducts and their amide and ester derivatives may also be usefully employed. Illustrative examples of such compounds and complexes are set out below:



22

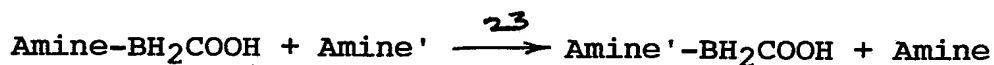


The organic boron compounds usefully employed in the broad practice of the present invention may be readily synthesized by known and conventional synthesis techniques.

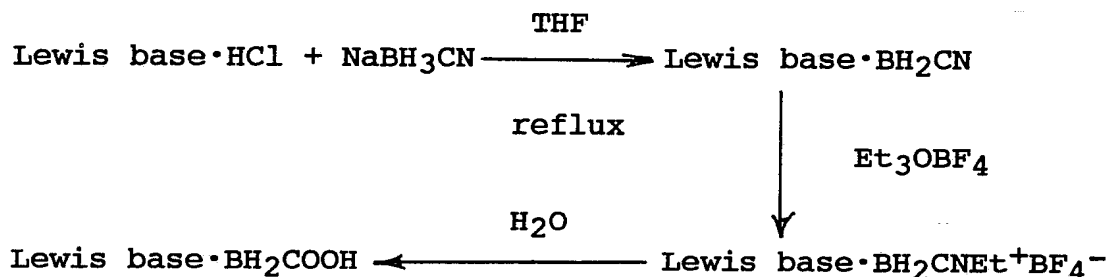
In some instances, it may be desirable to synthesize Lewis base-carboxyborane adducts having a very hydrophobic Lewis base portion of the molecule. Such hydrophobicity may be important for purposes of achieving suitable bioactivity and for enhancing the cellular uptake of the compound.

A bulky Lewis base portion of the molecule may also enhance activity, by obtaining a better steric fit with the active centers of enzymes that are inhibited in the action of the anti-osteoporosis or other disease-combatting agent. Depending on the enzymes responsible for the onset and progression of osteoporosis in the animal (mammalian) subject, it may be desirable to correspondingly size the Lewis base portion of the organic boron compound so as to effectively occupy the active sites of such enzymes. In addition, it may be desirable in some instances to utilize an anti-osteoporosis agent including a multiplicity of Lewis base boron adducts, e.g., carboxyborane compounds, having differently-sized Lewis based moieties in the respective compounds, e.g., alkylamine boron compounds with different alkyl groups associated therewith, as for example methyl, n-propyl, and branched alkyl groups.

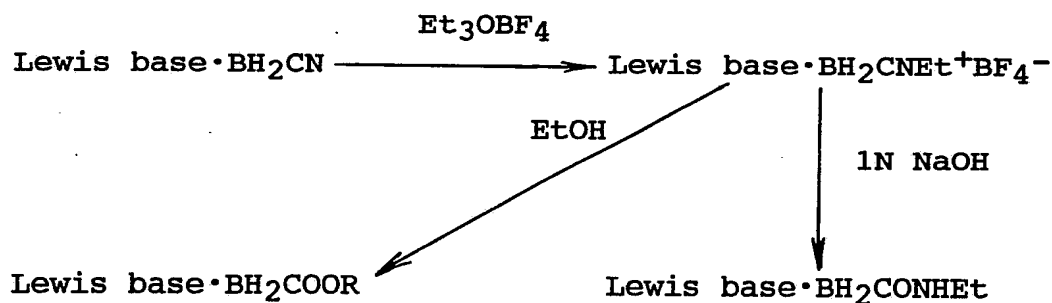
Base exchange reactions may be employed for synthesis of such boron compounds having selected Lewis base moieties:



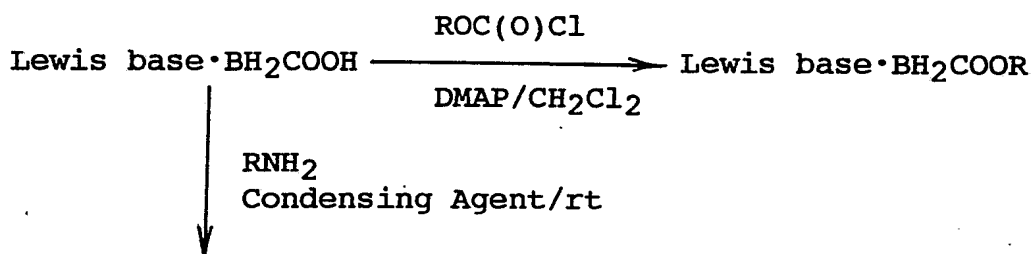
Alternatively, such Lewis base carboxyborane compounds may be formed, in the case of tertiary amines or phosphines, by intermediate formation of Lewis base-cyanoborane adducts, as shown below:



Derivatives of carboxyboranes, e.g., amides (including peptides) and esters can be readily prepared via several known methods, such as amine exchange and from amine-cyanoboranes, as shown in the reaction scheme set out below:

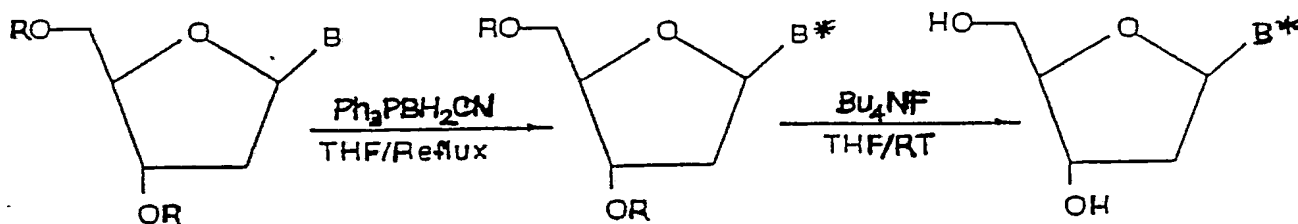


or such derivatives of carboxyboranes may be synthesized directly from amine-carboxyboranes as shown in the reaction scheme below:



Lewis base $\cdot \text{BH}_2\text{CONHR}$

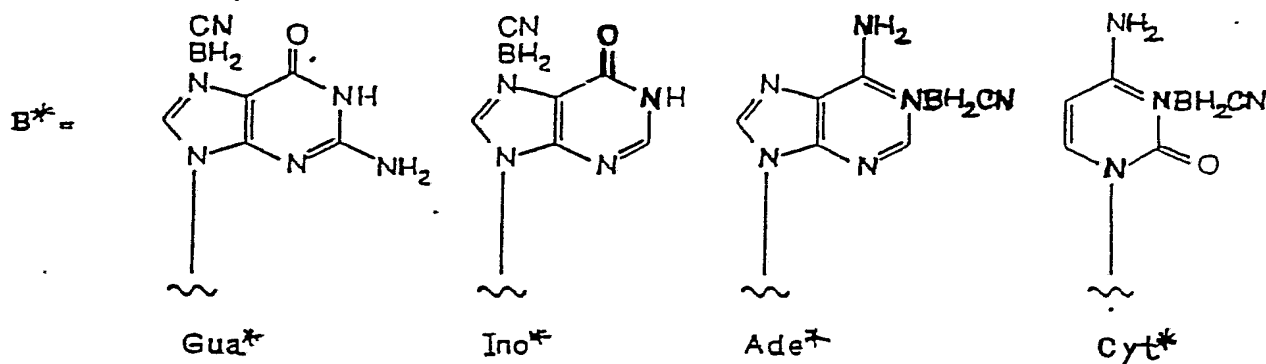
Boronated nucleosides usefully employed as organic boron compounds in the practice of the present invention may suitably be formed as shown below:



wherein:

R = $\text{Si}(\text{CH}(\text{CH}_3)_2)_3$;

B = Gua (a), Ino (b), Ade (c), Cyt (d) or Thy (e); and



25

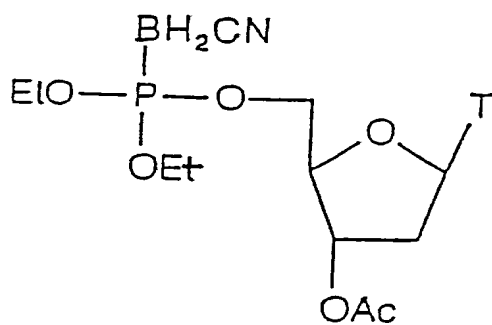
Illustrative nucleoside and nucleoside compounds are specified in Tables A and B below:

TABLE A: STRUCTURE OF NUCLEOSIDE COMPOUNDS

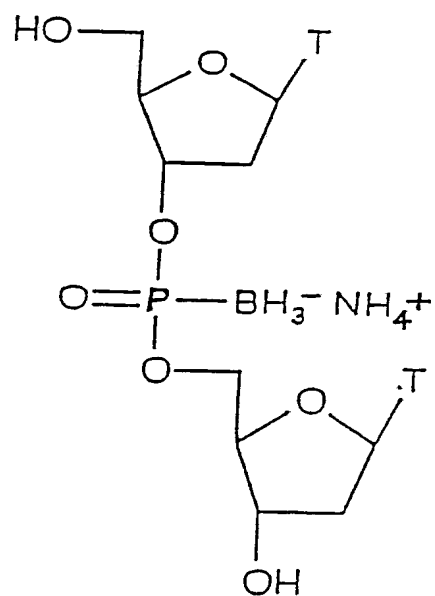
Compound Reference No.	Deoxyribose		Nucleoside Base		
	3'	5'	N ₁	N ₃	N ₇
29. Ino	OSi(CH(CH ₃) ₂) ₃	OSi(CH(CH ₃) ₂) ₃	H	--	--
30. Ino	OH	OH	H	--	BH ₂ CN
31. Ino	OSi(CH(CH ₃) ₂) ₃	OSi(CH(CH ₃) ₂) ₃	H	--	BH ₂ CN
32. Gua	OSi(CH(CH ₃) ₂) ₃	OSi(CH(CH ₃) ₂) ₃	H	--	--
33. Gua	OH	OH	H	--	BH ₂ CN
34. Gua	OSi(CH(CH ₃) ₂) ₃	OSi(CH(CH ₃) ₂) ₃	H	--	BH ₂ CN
35. Ade	OSi(CH(CH ₃) ₂) ₃	OSi(CH(CH ₃) ₂) ₃	H	--	--
36. Ade	OH	OH	BH ₂ CN	--	--
37. Ade	OSi(CH(CH ₃) ₂) ₃	OSi(CH(CH ₃) ₂) ₃	BH ₂ CN	--	--
38. Cyt	OSi(CH(CH ₃) ₂) ₃	OSi(CH(CH ₃) ₂) ₃		N ₃	--
39. Cyt	OH	OH	--	BH ₂ CN	--
40. Cyt	OSi(CH(CH ₃) ₂) ₃	OSi(CH(CH ₃) ₂) ₃	--	BH ₂ CN	--
41. Cyt	H	OSi(CH(CH ₃) ₂) ₃	--	----	--
42. Cyto	H	OSi(CH(CH ₃) ₂) ₃	--	BH ₂ CN	--
43. T	-O-C(O)CH ₃	PH ₃ PBH ₂ C(O)O	--	----	--

²⁶
TABLE B

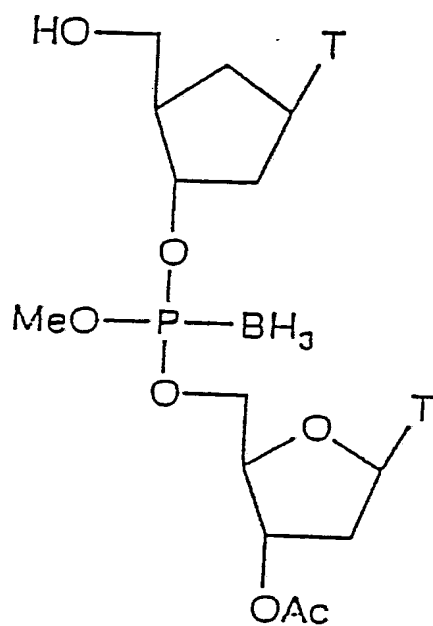
T = Thymidine



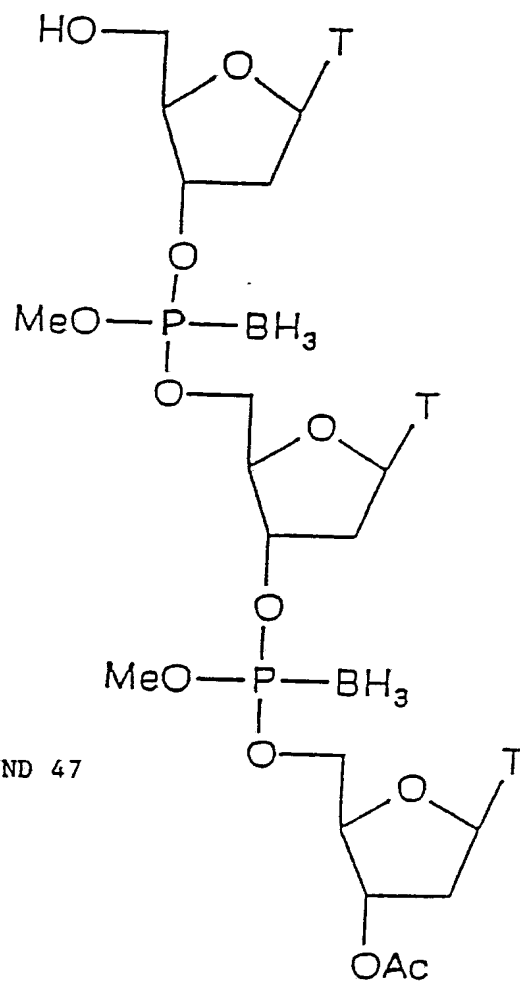
Compound 44



Compound 46



Compound 45



COMPOUND 47

Boron analogs of amino acids and related compounds in respect of the present invention have been found particularly useful in lowering blood and urine hydroxyproline levels, in lowering urine calcium excretion, in stabilizing lysosomal hydrolytic enzymatic activities, in inhibiting proteolytic enzymes (e.g., trypsin, collagenase, elastase, etc.), and in inhibiting prostaglandin synthetase activity while elevating cAMP levels.

In addition to anti-osteoporosis activity, many potentially useful organic boron compounds suitably employed in the practice of the present invention have other pharmacological and pharmaceutical activity, including anti-inflammatory, anti-hyperlipidemic, and antineoplastic activity. Accordingly, such compounds also have utility in treating mammals for inflammation, hyperlipidemia, and neoplasia conditions, when such conditions are present in the mammalian subject being treated with such anti-osteoporosis agents.

In this respect, inflammation and the subsequent biochemical and physiological changes associated therewith have been shown to be present in the incidence and development of a number of disease states. Not all facets of the inflammation process are present in each disease state. With an increased understanding of the prostaglandin, thromboxane and leukotriene systems, it known that inflammation plays a role in cystic fibrosis, neonatal hypoxemia, pulmonary hypertension, adult respiratory distress syndrome, psoriasis, spondyloarthritis, rheumatoid arthritis, gout, inflammatory bowel disease, and myocardial infarctions. In consequence, the organic boron compounds employed in the practice of the present invention which exhibit anti-inflammatory activity may be usefully employed to combat such disease states with which inflammation is associated.

A preferred aspect of the present invention comprehends a method of combatting osteoporosis in an animal subject, e.g., mammal, in need of such treatment, by administering to the animal subject an osteoporosis-combatting amount of the organic boron compound.

Subjects to be treated by the disease-combatting method of the present invention include both human and non-human animal (e.g., bird, dog, cat, cow, horse,) subjects, and are preferably mammalian subjects.

Animal subjects are administered the organic boron compounds at a daily dose of preferably at least about 0.1 mg/kg weight of the animal subject, more preferably at least about 0.5 mg/kg, and most preferably at least about 2 mg/kg. The daily dose preferably is not more than about 200 mg/kg, more preferably not more than about 100 mg/kg, and most preferably not more than about 50 mg/kg.

In practicing the method of the present invention, the organic boron compounds may be administered per se or as components of a pharmaceutically acceptable composition. When used in medicine, the form of the organic boron compounds should be both pharmacologically and pharmaceutically acceptable.

Thus, the present invention may be practiced with the boron compounds being provided in pharmaceutical formulations, both for veterinary and for human medical use, comprising the active agent (the organic boron compound) together with one or more pharmaceutically acceptable carriers thereof and optionally any other therapeutic ingredients. The carrier(s) must be pharmaceutically acceptable in the sense of being compatible with the other ingredients of the formulation and not unsuitably deleterious to the recipient thereof. The active agent is provided in an amount effective to achieve the desired pharmacological effect, as described above, and in a quantity appropriate to achieve the desired daily dose.

29

The formulations include those suitable for oral, rectal, topical, nasal, ophthalmic, or parenteral (including subcutaneous, intramuscular, and intravenous) administration. Formulations suitable for parenteral administration are preferred.

The formulations may conveniently be presented in unit dosage form and may be prepared by any of the methods well known in the art of pharmacy. All methods include the step of bringing the active compound into association with a carrier which constitutes one or more accessory ingredients. In general, the formulations may be prepared by uniformly and intimately bringing the active compounds into association with a liquid carrier, a finely divided solid carrier, or both, and then, if necessary, shaping the product into desired formulations.

Formulations of the present invention suitable for oral administration may be presented as discrete units such as capsules, cachets, tablets, or lozenges, each containing a predetermined amount of the active ingredient as a powder or in the form of granules; or as a suspension in an aqueous liquor or a non-aqueous liquid, such as a syrup, an elixir, an emulsion, or a draught.

A tablet may be made by compression or molding, optionally with one or more accessory ingredients. Compressed tablets may be prepared by compressing in a suitable machine, with the active compound being in a free-flowing form such as a powder or granules which optionally is mixed with a binder, disintegrant, lubricant, inert diluent, surface active agent, or discharging agent. Molded tablets comprised of a mixture of the powdered active compound with a suitable carrier may be made by molding in a suitable machine.

30

A syrup may be made by adding the active compound to a concentrated aqueous solution of a sugar, for example sucrose, to which may also be added any accessory ingredient(s). Such accessory ingredient(s) may include flavorings, suitable preservatives, agents to retard crystallization of the sugar, and agents to increase the solubility of any other ingredient, such as a polyhydroxy alcohol, for example glycerol or sorbitol.

Formulations suitable for parenteral administration conveniently comprise a sterile aqueous preparation of the active compound, which preferably is isotonic with the blood of the recipient (e.g., physiological saline solution).

Nasal spray formulations comprise purified aqueous solutions of the active compound with preservative agents and isotonic agents. Such formulations preferably are adjusted to a pH and isotonic state compatible with the nasal mucous membranes.

Formulations for rectal administration may be presented as a suppository with a suitable carrier such as cocoa butter, hydrogenated fats, or hydrogenated fatty carboxylic acids.

Ophthalmic formulations are prepared by a similar method to the nasal spray, except that the pH and isotonic factors are preferably adjusted to match that of the eye.

Topical formulations comprise the active compound dissolved or suspended in one or more media, such as mineral oil, petroleum, polyhydroxy alcohols, or other bases used for topical pharmaceutical formulations.

In addition to the aforementioned ingredients, the formulations of this invention may further include one or more accessory ingredient(s) selected from diluents, buffers, flavoring agents, binders, disintegrants, surface active agents,

31

thickeners, lubricants, preservatives (including antioxidants), and the like.

The following Examples are provided to illustrate the present invention, and should not be construed as limiting thereof. Compounds are identified in the first instance by a name or a chemical formula, and a reference number, and may thereafter be identified solely by reference number, for ease of reference.

For ease of reference in respect of the following examples, the test procedures for the *in vivo* and *in vitro* tests are summarized below:

In Vivo Rodent Screens:

Anti-inflammatory Screen- Cf₁- male mice-Winter's Test
2% carrageenan S.C. plantar surface of hind foot,
drugs administered @ 8 or 10 mg/kg I.P. 2X

Anti-pyretic Screen-Sprague Dawley male rats
44% Baker's yeast S.C.
drugs administered @ 2.5 or 5 mg/kg/ I.P.
rectal temperature taken at 2, 4, and 6 hr.

Writhing reflex- Cf₁-male mice- 0.6% acetic acid I.P.
drugs administered @ 20 mg/kg/ I.P.
20 min. later - the # of stretches/10 min.

Hot Plate Tail Flick Test-Cf₁-male mice
drugs administered @ 20 mg/kg/ I.P. 5 min later -
determined time in seconds to lift tail.

Chronic Adjuvant Arthritis Screen- Sprague Dawley male
rats. Mycobacterium butyricum in mineral oil S.C.
drugs administered @ 2.5 mg/kg/day for 3 weeks.

Anti-pleurisy Screen- Sprague Dawley male rats
0.316% Evans blue + carrageenan in pleural cavity
drugs administered at 2.5 mg/kg after 1, and 3 hr.

Ulcerogenic Test- Sprague Dawley male rats
drugs administered @ 2.5 mg/kg/day for 3 weeks
gastric and duodenum mucosa examined for lesions.

In Vitro Mode of Action Study

32

- Tissues:
1. Cf₁ male mouse hepatic 10% homogenates in 0.25M sucrose+0.001M EDTA, pH 7.2.
 2. PMNs-polymorphonuclear neutrophils-rat peritoneal cavity 0.5% oyster glycogen.
 3. Mouse macrophages J774A.1 BALB/c
 4. Osteoporosis Human Fibroblast-CRL-1140, Be SA1
 5. Human peripheral leukocytes, RPMI-1788

Lysosomal Enzymes - free and total [triton X-100].

1. Acid phosphatase -beta glycerol-3-phosphate, pH 5.0, released IP 720nm.
2. Acid Cathepsin D -azocasein-pH 5.0, hydrolytic azo-peptide product 366nm.
3. Aryl sulphatase- p-nitrocatechol sulfate, pH 5.0
5. 8 p-nitro-catechol product 510nm.

Proteolytic Enzymes-

1. Trypsin- N-benzoyl-L-arginine ethyl ester pH 8.0, hydrolytic product 253 nm.
2. Elastase- N-succinyl-L-alanyl-L-alanine-p-nitroanilide, pH 8.0, p-nitro anilide 410 nm.
3. Collagenase I, Clostridium histolyticum, bone, skin, tendon, blood vessel, dentine, GI. substrate: rat collagen, N-[propionate-2-3-³H] propionylated measured as dpm released.
4. Collagenase II, Clostridium histolyticum, cartilage collagen.

cAMP levels Gilman's radioimmune assay.

³H(G)Cyclic-3', 5'-adenosine monophosphate.

Prostaglandin synthetase purified beef seminal vesicle

³H arachidonic acid (86.2 Ci/mmol), tlc separation.

5'-Lipoxygenase-³H-arachidonic acid, calcium ionophore A 23187, tlc-5-hydroxy-eicostetraenoic acid, [5-HETA].

Oxidative phosphorylation- Gilson oxygraph-substrate- Succinate or alpha ketoglutarate measured state 3 and 4, basal and ATP coupled respiration.

Chemotaxis PMNs migration Nelson's method E. coli endotoxin- migration measured in microns.

Protection against free radicals generation-Fenton reaction.

Set out below, in respect of various tests hereinafter referenced, is a listing of literature-based specifications of the methodology therefor:

<u>Test</u>	<u>Reference</u>
percent inhibition anti-inflammation test-Cf ₁ mouse	Winter, C.A., et al, Proc.Soc. Exp. Biol.Med., 111, 544, 1962; Roszkowski, A. P., et al, J. Pharmacol.Exp.Ther., 179, 114, 1971.
porcine pancreatic elastase activity <i>in vitro</i>	Kleinerman, J., et al, Am. Rev. Respiratory.Dis.,121,381, 1980.
Trypsin (BAEE) activity - <i>in vitro</i>	Schleuning, W.D., et al, Methods in Enzymol. XLV, p.330, 1976.
Cathepsin azo casein activity - <i>in vitro</i>	Hall, I.H., et al, Jn. Acta Pharm. Nord., 2, 387, 1990.
Acid phosphatase activity - <i>in vitro</i>	Hall, I.H., et al, J.Med. Chem. 19, 1257, 1976.
Aryl sulfatase activity - <i>in vitro</i>	Roy, A.B., Biochem. J., 53, 12, 1953.
Elastase activity - <i>in vitro</i>	Kleinerman, J., et al, <i>Ibid.</i>
Uptake of boron analogs of amino acids, peptides and nucleosides in human and Chinese hamster ovary cells grown in tissue culture, and cytotoxicity against growth of human osteosarcoma and human osteoporosis fibroblastic cells	Hu, C.L.,et al, Anal. Biochem., 88,683, 1978; Murthy, G., et al Biochem. J., 199, 807, 1981; Cawston, T.E., et al, Anal. Biochem., 99, 340, 1979.
Urine ketosteroid	Sigma Kit No. 270, Sigma Chemicals Co., St. Louis, Mo.
Calcium serum and urine levels	Sigma Kit No. 587, Sigma Chemicals Co., St. Louis, Mo.
Hydroxyproline serum and urine levels	Podenphant, J., et al, Clin. Chemica. Acta, 142, 145, 1984.
Phosphorus serum and urine levels	Chen, P.S., et al, Anal. Chem., 28, 1756, 1956.
Anti-arthritis effect - rats	Waxman, B.H., et al, J. Immunol., 85, 403, 1960.
Writhing reflex - mice	Hendershot, L.C., et al, J.

34

	Pharm. Expt. Therp., 125, 237, 1959.
Tail Flick test - mice	Hall, I.H., et al, J. Pharm. Sci., 69, 1451, 1980.
Anti-pleurisy effect - rats Expt.	Sancilo, L.F., Pros. Soc. Biol. and Med., 127, 597, 1968.
Fenton reaction	Kurchandy, E., et al, Intl. J. of Pharmaceutic., 57, 173, 1989.
Prostaglandin synthesis	Glatt, N., et al, Agents and Actions, 7, 321, 1977;
Tomlinson	R.V., et al, Biochem. Res. Comm., 46, 352, 1972.
Biophys.	
5'-lipoxygenase	Mylari, B.L., et al, J. Med. Chem., 33, 2019, 1990.

EXAMPLE I

In this test, *in vivo* anti-inflammatory activity in rodents was evaluated for the compounds and with the results set out in Table I below.

Table 1

In Vivo Anti-inflammatory Activity in Rodents

35

% Control

(N=6 Compound	LD50 mg/kg	Anti- inflammatory	Writhing arthritic	Anti- pleurisy
1. $O(CH_2CH_2)_2NHBH_3$	475	55	15	33
2. $(CH_3)_3N^+BH_2CN$	70	42	18	4
3. $(CH_3)_3N^+BH_2COOH$	1800	79	29	53
4. $[Na(H_3N^+BH_2(CN)_6)]I$	100	57	12	0
5. $[CH_2N(CH_3)_2BH_2COOH]_2$	1000	58	55	24
6. $(CH_3)_3NBH_2COOCH_2CH_3$	140	74	89	13
7. Indomethacin 10mg/kg	28	22	43	27

The compounds tested did not lower induced elevated body temperature of rats. There was evidence that gastrointestinal lesions were produced by the agents in rats. There was no effect on chemotaxis.

EXAMPLE II

In this example, biochemical effects of the organic boron compounds of Example I were evaluated for mouse liver and PMNs lysosomal enzyme activities, with the results shown in Table II below.

Table II

(N=6) 5 X 10 ⁻⁶ M Compound	Mouse Liver		Rat PMNs		PMNs cAMP
	Acid Phosph.	Cathep.	Acid Phosph.	Cathep.	
1	75+8	107+6	79+5	93+7	107
2	69+4	6+2	35+5	4+2	245
3	82+5	56+6	50+3	14+4	99
4	65+3	3+1	34+6	3+3	361
5	69+5	23+6	84+4	52+4	155
6				16+3	
Indomethacin 86+4		67+6	100+2	100+1	80
0.753 ug Pi		7.17ug pro.	0.26mg Pi	0.225mg	748

		36		
/hr/mg	/hr/mg	/hr/10 ⁻⁷	/hr/10 ⁻⁷	p.M/
wet tissue	wet tissue	cells	cells	10 ⁻⁷
				cells

EXAMPLE III

In this example, prostaglandin synthetase activity and hepatic oxidative phosphorylation were evaluated for the compounds of Example I, with the results shown in Table III below.

		<u>Table III</u>			
		% Control		Phosphorylation	
		Hepatic Oxidative		alpha-Ketoglutarate	
10 ⁻⁶ M	Prostaglandin	Succinate		State 4	State 3
<u>Compound</u>	<u>synthetase</u>	State 4	State 3		
1	100+5	115+5	66+10	97+29	50+11
2	59+6	133+20	51+20	85+21	41+9
3	93+3	122+14	63+4	127+22	70+20
4	42+5	110+5	31+10	101+25	37+10
5	60+6	80+11	57+16	122+15	48+30
6	--	119+18	61+19	126+51	54+8
Indomethacin	64+2				
[10 ⁻⁴ M]					
Control	100+4	100+6	100+4	100+8	100+9
	6564 DPM/	9.19 ul/	13.66ul/	3.38ul	4.93.ul/
	hr/mg	hr/mg	hr/mg	hr/mg	hr/mg

EXAMPLE IV

In this test, *in vivo* activity was determined for rodents with respect to anti-inflammatory activity and writhing reflex. The results are shown in Table IV below.

<u>Table IV</u>				
<i>In Vivo</i> Activity 8 mg/kg I.P.				
		%Control		Writhing Reflex
		Anti-Inflammatory Activity		Cf ₁ Mice
Compounds		Mice	Sprague Dawley	
Rats				
1'. (CH ₃) ₃ CNH ₂ BH ₃		41	----	18
2'. CH ₃ NH ₂ BH ₂ COOH		54	----	31
3'. (CH ₃) ₂ NHBH ₂ COOH		65	55	2.0

4'. (CH ₃) ₃ NBH ₂ COOH	58	37	59	11.5
5'. (CH ₃) ₃ NBH ₂ COOCH ₃	58			2.0
6'. C ₁₈ H ₃₇ N(CH ₃) ₂ BH ₂ COOH	80			14.1
7'. C ₁₆ H ₃₃ N(CH ₃) ₂ BH ₂ COOH	58			54.0
8'. (C ₆ H ₅) ₃ PBH ₂ COOH	40			18.7
9'. (CH ₃) ₂ NHBH ₂ C(O)NHC ₂ H ₅	59		41	26.9
10'. (CH ₃) ₂ NHBH ₂ CN	49		61	14.7
11'. (CH ₃) ₃ NBH ₂ CN	42		65	18.0
12'. O(CH ₂ CH ₂) ₂ NHBH ₃	55			15.2
13'. Na ₂ BH ₃ COO	42		55	17.4
14'. (CH ₃) ₃ NBH ₂ C(O)NHOH°				
HB(C ₆ H ₅) ₄	56		60	50.0
15'. C ₅ H ₅ NBH ₂ COOH	51			50
16'. CH ₃) ₃ NB(CN) ₂ CH ₃	59			33.9

EXAMPLE V

In this test, the effects of selected boron compounds of Example IV were evaluated for mouse hepatic lysosomal enzyme activities, for acid phosphatase, cathepsin D, and aryl sulphatase, the results are shown in Table 5 below.

Table V

The Effects of Boron Derivatives on Mouse Hepatic Lysosomal Enzyme Activities 60 min Incubation IC₅₀ values 10⁻⁶ M.

Compound #	Acid Phosphatase	Cathepsin D	Aryl Sulphatase
1'	7.7	5.8	
3'	7.89	3.76	
5'	7.37	6.59	
6'	9.67	6.21	
7'	8.86	2.82	
10'	8.90	3.20	
11'	3.51	0.72	
12'	8.95	0.88	
14'	4.22	3.66	5.85
15'	10.02	4.80	

EXAMPLE VI

32

Selected boron compounds from Example IV were evaluated for their effects on mouse hepatic proteolytic enzyme activity and 5'-lipoxygenase activity. The results are shown in Table VI below.

Table VI

The Effects of Boron Derivatives on Mouse Hepatic Proteolytic Enzymes and 5'-Lipoxygenase Activities

60 min Incubation		IC ₅₀ values 10 ⁻⁶ M.	
Compound #	Trypsin	Elastase	5'-lipoxygenase
2'			64.6
3'	0.83	25.9	
5'	1.19	37.4	66.6
6'	0.23	22.9	
7'	1.16	49.6	55.8
9'			43.5
10'			22.9
12'	0.51	4.4	66.9

EXAMPLE VII

The effects of selected boron compounds of Example IV were tested for their effects on mouse macrophage cultured cells, with respect to activity of cathepsin D, acid phosphatase, and aryl sulphatase. The results are shown in Table VII below.

Table VII

The Effects of Boron Derivatives on Mouse Macrophage Cultured Cells Grown in DMEM +10% FCS +P/S, 10⁻⁶ cells

60 min Incubation		IC ₅₀ values 10 ⁻⁶ M.	
Compound #	Cathepsin D	Acid Phosphatase	Aryl Sulphatase
1'	8.08	---	4.62
2'	9.45	0.90	8.30
3'	6.39	4.75	----
4'	6.71	1.04	7.42
5'	8.29	3.55	----
6'	5.10	5.34	----

		39	
7'	7.18	0.94	9.71
8'	5.52	1.08	8.58
9'	3.95	1.12	9.27
10'	5.54	1.13	9.00
11'	6.34	1.05	9.29
12'	0.76	3.18	----
13'	4.57	0.82	5.43
14'	1.69	3.96	1.37
16'	6.89	1.10	8.48

EXAMPLE VIII

The effects of selected boron compounds of Example IV were evaluated on proteolytic enzyme activity and prostaglandin cyclooxygenase activity of mouse macrophages. Results are set out in Table VIII below.

Table VIII

The Effects of Boron Derivatives on Proteolytic Enzyme Activities and Prostaglandin Cyclooxygenase Activity of Mouse Macrophages 60 min. Incubation IC₅₀ values X 10⁻⁶M.

Compound #	Trypsin BAEE	Elastase	Prostaglandin Cyclooxygenase
1'	2.09	0.22	4.19
2'	2.34	2.32	3.50
3'	3.10	2.67	2.91
4'	2.78	2.14	2.81
5'	3.23	8.76	2.41
6'	2.07	6.29	2.51
7'	1.26	1.80	2.55
8'	1.77	3.04	3.53
9'	2.03	3.29	5.19
10'	2.44	2.53	5.92
11'	1.41	1.35	5.88
12'	2.39	5.94	1.47
13'	2.25	3.07	6.79
14'	2.14	1.49	1.61
16'	1.62	2.02	3.05

40

3H-Arachidonic acid conversion to Pg-E₂ was reduced 43% in CF₁ hepatic liver, and 29% in macrophage by compound 7'. Compounds 7' and 8' reduced hepatic Pg-E₂ synthesis by 32% and macrophage Pg-E₂ synthesis by 20%. When osteoporosis fibroblasts (obtained from American Tissue Culture) were examined, Compounds 7'. and 8'. were found to be potent inhibitors of lysosomal and proteolytic enzymes of these cells, as shown by the results in Table XXIII.

Table VIIIA

Osteoporosis Fibroblasts Enzyme Activity In Vitro
IC₅₀ X 10⁻⁶ M

<u>Compd.#</u>	<u>Trypsin</u>	<u>Cathepsin</u>	<u>Acid</u>	<u>Aryl</u>
<u>Elastase</u>	<u>(BAEE)</u>	<u>Azo-casein</u>	<u>Phosphatase</u>	<u>Sulfatase</u>
7'	7.4	2.06	16.6	9.01
3.86				
8'	5.7	6.42	15.3	9.33
1.96				

EXAMPLE IX

Selected compounds of Example IV were tested to determine their effects on commercial enzyme preparations, including *Clostridium histolyticum* type I and II collagenases, porcine pancreatic elastase, and beef prostaglandin cyclooxygenase. Results are set out in Table IX below.

Table IX

Effects of Boron Derivatives on Commercial Enzyme Preparations

Compound	IC ₅₀ values X 10 ⁻⁶ M.		
	<u>Clostridium</u>	Porcine	Beef
	<u>histolyticum</u>	Pancreatic	Prostaglandin
	Collagenase	Elastase	Cyclooxygenase
	Type I	Type II	

2'		101	41	
3'	667		37.3	3.25
5'	797	124	32.8	2.98
6'	663		27.6	1.92
7'	615	109	49.7	2.86
8'		107		
10'		106		
11'		113		5.9
12'	783	896	14.9	2.36
14'				1.30
15'				7.60
16'		110		

EXAMPLE X

Selected boron compounds of Example IV were tested to determine their effects on human osteoporosis fibroblasts tissue culture, with respect to cathepsin D, acid phosphatase, and aryl sulphatase. Results are shown in Table X below.

Table X

The Effects of Boron Derivatives on Human Osteoporosis Fibroblasts Tissue Culture Grown in DMEM +10% FCS + P/S
60 min Incubation IC₅₀ values X 10⁻⁶ M.

Compound #	Cathepsin D	Acid Phosphatase	Aryl Sulphatase
1'	6.42	10.2	9.14
4'	1.10	17.6	8.59
7'	2.06	16.6	9.01
8'	6.42	15.3	9.33
9'	1.93	8.6	7.63
10'	1.28	8.7	7.91
11'	2.01	15.9	8.87
12'	4.40	10.3	8.99
13'	1.19	6.5	8.19
15'	8.16	18.3	8.16

EXAMPLE XI

In this example, certain boron compounds of Example IV were evaluated to determine their effect on proteolytic enzymes and prostaglandin cyclooxygenase activities of human osteoporosis fibroblasts. The activity values are set out in Table XI below.

42
Table XI

The Effects of Boron Derivatives on Proteolytic Enzymes and Prostaglandin Cyclooxygenase Activities of Human Osteoporosis Fibroblasts 60 min Incubation IC₅₀ values X 10⁻⁶ M.

Compounds	Trypsin BAEE	Elastase	Prostaglandin Cyclooxygenase
1'	7.00	3.15	3.94
4'	6.14	1.31	4.24
7'	7.40	3.86	6.77
8'	5.70	1.96	5.49
9'	4.36	0.98	8.05
10'	6.43	3.36	5.58
11'	3.98	3.29	4.26
12'	7.88	1.84	3.41
13'	7.51	3.01	5.51
16'	3.35	3.60	9.29

EXAMPLE XII

In this test, selected compounds of Example IV were tested to determine their effects on human leukocyte tissue culture cells, with respect to 5'lipoxygenase and cathepsin. Results are shown in Table XII below.

Table XII

The Effects of Boron Derivatives on Human Leukocytes Tissue Culture Cells Grown in RMPI 1640 + 15% FCS + P/S
60 min Incubation IC₅₀ values X 10⁻⁵ M.

Compound#	5'Lipoxygenase	Cathepsin
2'	5.83	7.03
5'	5.37	5.97
7'		6.46
8'	4.77	7.25
10'		5.38
11'	6.42	7.71
12'		7.28
16'	3.28	6.52

43

EXAMPLE XIII

In this example, the boron compounds identified in Table XIII below were tested for *in vivo* effects on serum and urine levels of hydroxyproline, calcium and inorganic phosphorous of Cf₁ male mice, at the dosage stated in the table, with the results set forth therein.

Table XIII

The In Vivo Effects of Boron Derivatives on Serum and Urine Levels of Hydroxyproline, Calcium and Inorganic Phosphorous of Cf₁ Male Mice Dosed at 8 mg/kg/day I.P. 14 Days

Compounds urine	(N=6)% Control		Calcium serum	Phosphorus urine	Phosphorus serum
	Hydroxyproline serum	urine			
(CH ₃) ₂ N(C ₁₆ H ₃₃)BH ₂ COOH	84.1	28.7	---	80.7	---

Ph ₃ PBH ₂ COOH	60.5	30.0	---	83.5	---

(CH ₃) ₂ N(C ₁₈ H ₃₇)BH ₂ COOH	76.4	60.6	135.4	64.4	86.2
65.4					
CH ₃ NH ₂ BH ₂ COOH	71.7	42.5	109.7	50.8	81.6
39.6					
CH ₃ NH ₂ BH ₂ COOCH ₃	68.0	144.1	105.1	176.9	65.3
136.8					
(CH ₃) ₃ NBH ₂ COOCH ₃	79.4	51.4	110.7	52.6	81.6
54.4					
CH ₃ CH ₂ NH ₂ BH ₂ COOH	89.1	69.2	121.0	61.2	64.3
78.0					
(CH ₃) ₂ NHBH ₂ COOCH ₃	84.4	50.5	125.4	80.7	42.8
67.8					

EXAMPLE XIV

In this example, the metal complexes of boron compounds are identified as compounds 21-28 below.

44

<u>Reference No.</u>	<u>Complex</u>
21.	$\text{Na}_2\text{BH}_3\text{COO}$
22.	$\text{Na}(\text{CH}_3)_3\text{NBH}_2\text{COO} \cdot (0.25\text{CH}_3\text{OH})$
23.	$\text{Na}(\text{CH}_3)_2\text{NHBH}_2\text{COO} \cdot (0.45\text{H}_2\text{O})$
24.	$[\text{Fe}_3\text{O}((\text{CH}_3)_3\text{NBH}_2\text{COO})_6(\text{CH}_3\text{OH})_3]\text{NO}_3 \cdot \text{CH}_3\text{CN}$
25.	$[\text{Fe}_3\text{O}((\text{CH}_3)_3\text{NBH}_2\text{COO})_6(\text{H}_2\text{O})_3]\text{Cl}$
26.	$[\text{Cr}_3\text{O}((\text{CH}_3)_3\text{NBH}_2\text{COO})_6(\text{H}_2\text{O})]\text{NO}_3 \cdot \text{CH}_3\text{OH} \cdot \text{CH}_3\text{CN}$
27.	$\text{Cis}-[\text{Co}(\text{en})_2((\text{CH}_3)_3\text{NBH}_2\text{COO})_2]\text{Cl} \cdot 2.5\text{H}_2\text{O} \cdot (0.5\text{CH}_3\text{OH})$
28.	$\text{Ca}((\text{CH}_3)_3\text{NBH}_2\text{COO})\text{NO}_3 \cdot \text{CH}_3\text{COCH}_3 \cdot (0.5\text{H}_2\text{O})$

were tested to determine their *in vivo* anti-inflammatory effects in the test, and with the results, identified in Table XIV below.

Table XIV

Compound #	Anti-Inflammation <u>Cf₁</u> <u>Mice</u>	Anti-Arthritis <u>Rats</u>	Writhing Reflex <u>Mice</u>	Tail Flick <u>Mice</u>	Anti-Pleurisy <u>Rats</u>
21	41.7	55.2	---		
22	73.4		76.5	101	
23	68.5		70.4	156	
24	81.6		42.9	338	
25	74.2		36.4	599	
26	58.5	78.0	85.4	184	40.0
27	49.6	70.0	66.2	150	96.3
28	65.0		66.4	169	50.1

EXAMPLE XV

The compounds of Example XIV (metal complexes of boron derivatives, Nos. 21-28) were evaluated for their effect on mouse hepatic lysosomal enzyme activities, for cathepsin D, acid phosphatase, and aryl sulphatase. Results are shown in Table XV below.

Table XV

The Effects of Metal Complexes of Boron Derivatives on Mouse Hepatic Lysosomal Enzyme Activities IC₅₀ values X 10⁻⁶ M

45

60 min Incubation Compound #	Cathepsin D	Acid Phosphatase	Aryl Sulphatase
21	6.19	4.00	4.34
22	6.69	3.56	5.15
23	7.65	3.58	2.83
24	6.84	5.60	2.57
25	8.17	4.14	2.33
26	5.47	6.99	7.73
27	7.80	4.25	5.89
28	4.58	7.66	3.05

EXAMPLE XVI

The metal complexes of boron derivatives of Example XIV were evaluated for their effects on proteolytic enzymes and prostaglandin cyclooxygenase activity. Results are set out in Table XVI below.

Table XVI

The Effects of Metal Complexes of Boron Derivatives on Proteolytic Enzyme and Prostaglandin Cyclooxygenase Activity 60 min Incubation IC₅₀ values X 10⁻⁶ M.

Compound #	Mouse Hepatic Trypsin	Porcine Seminal Vesicles Pg.cyclooxygenase	Commercial Collagenase
21			
22	9.98	2.40	490
23	9.95	3.10	506
24	9.93	2.90	478
25	9.91	4.17	475
26	9.96	2.14	567
27	9.88	4.01	522
28	9.99	2.57	495

EXAMPLE XVII

46

The metal complexes of boron derivatives of Example XIV were tested for their effects on mouse macrophage lysosomal enzyme activities, for cathepsin D, acid phosphatase, and aryl sulphatase. Results are set out in Table XVII below.

Table XVII

The Effects of Metal Complexes of Boron Derivatives on Mouse Macrophage Lysosomal Enzyme Activities 60 min Incubation
IC₅₀ values X 10⁻⁶ M.

Compound #	Cathepsin D pH 5.0	Acid Phosphatase	Aryl Sulphatase
21	4.57	0.82	5.43
22	1.92	2.00	1.33
23	2.28	1.42	1.60
24	2.85	2.09	1.95
25	3.39	2.44	2.75
26	2.49	2.48	1.20
27	3.83	2.92	1.95
28	2.38	3.08	2.38

EXAMPLE XVIII

The metal complexes of Example XIV were tested to determine their effects on mouse macrophage proteolytic enzyme and prostaglandin cyclooxygenase activities, yielding the results in Table XVIII below.

Table XVIII

The Effects of Metal Complexes of Boron Derivatives on Mouse Macrophage Proteolytic Enzyme and Prostaglandin Cyclooxygenase Activities 60 min Incubation
IC₅₀ values X 10⁻⁶ M.

Compound #	Trypsin BAEE	Elastase	Prostaglandin Cyclooxygenase
------------	-----------------	----------	---------------------------------

21	2.25	3.07	15.59
22	2.27	7.26	2.41
23	2.21	6.35	2.07
24	2.37	3.92	2.34
25	1.81	4.11	2.08
26	2.10	5.09	1.62
27	1.38	9.77	2.09
28	2.38	5.93	1.92

EXAMPLE XIX

In this example, deoxynucleoside boron derivatives of the structure specified in Tables A and B hereinabove as compound Nos. 29-47 were tested to determine their effects on inflammation processes. Results are shown in Table XIX below.

Table XIX

The Effects of Deoxynucleoside Boron Derivatives on Inflammation Processes

Compound #	Anti-inflammatory Activity 8 mg/kg % Control	Mouse Hepatic Cathepsin D IC ₅₀	Human Leukocyte 5' lipoxigenase IC ₅₀ values X 10 ⁻⁶	Leukocyte M.
29	49.2	79.6	31.8	8.85
30	75.3			
31	70.9			
32	55.4			
33	78.4			
34	76.5			
35	57.5	58.1	33.4	10.1
36	70.6			
37	63.1			
38	48.2	59.7	13.9	7.72
39	48.3	26.0	8.72	12.8
40	55.2	27.2	6.12	3.88
41	87.8			
42	63.0	30.6	7.31	6.64
43	66.0			

44	66.8
45	73.9
46	63.1
47	60.0

EXAMPLE XX

Boron analogs of amino acids, peptides and nucleosides are readily taken up in human and chinese hamster ovary cells grown in tissue culture. The cytotoxic effect of Compounds 7', 8', and 5', (identified in Example XX) against the growth of (ATCC) human osteosarcoma and human osteoporosis fibroblastic cells (as shown by the results in Table XXIV), evidences that these compounds are entering the cells. A boron-containing nucleoside analog was found in the bone at 1% of the administered dose in an *in vivo* experiment with mice. Thus, boron analogs of endogenous intermediate metabolites enter various tissue types, including bone.

Table XX
Cytotoxicity

<u>Compound #</u>	<u>ED-50 μg/ml</u>	
<u>Fibroblasts</u>	<u>Osteosarcoma</u>	<u>Osteoporosis</u>
7'.	2.47	7.39
8'.	2.65	5.3
5'.	5.13	7.09
14'.	1.14	1.21

Example XXI

Trimethylamine-carboxymethoxyborane, tetrakis- μ (trimethylamine-boranecarboxylato-bis(trimethylamine-carboxyborane-dicopper(II) and N,N-dimethyl-n-octadecylamine borane were evaluated for acute toxicity.

49

CF₁ male mice (\sim 28-30 gm) were treated at 1, 2 or 5 x the anti-inflammatory therapeutic dose i.p for 7 days. The mice were sacrificed by cervical dislocation. Food consumption (Ralston Purina Co.) was monitored daily and water was *ad libitum*. The mice were maintained on a 12 h cycle of light and dark daily at 22°C.

At the time of the sacrifice, the major organs were excised, trimmed of fat, weighed and expressed as 100 g of body weight. Blood was obtained from the carotid and centrifuged at 3500 g x 10 min to obtain the serum. Chemical or enzymatic assays were performed with Sigma Chemical Kits; urea nitrogen (BUN, No. 640), alanine amino transferase (SGPT, No. 505), alkaline phosphatase (AP, No. 104), glucose (No. 510), lactic dehydrogenase (LDH, No. 500), creatine phosphokinase (CP-kinase, No. 661), and total and direct bilirubin (No. 605), Serum triglycerides were determined with a diagnostic kit from Boehringer Mannheim; serum cholesterol was determined by the method of Ness et al (Clin. Chem. Acta 10, 229 (1964). Albumin and total protein were determined according to Lowery et al (J. Biol. Chem. 193, 265 (1951). Cholic acid and uric acid were determined as outlined by Tietz (Fundamentals of Clinical Chemistry, p. 249-1057, Saunders, Philadelphia Pa. 1976).

Amine borane compounds (0 to 100 mg/kg) were administered to CF₁ male mice as a single injection with six mice for each dosage. Mice were weighed daily and the number of deaths was recorded each day for a 14 day period. The LD₅₀ value was determined by the procedure of S.C. Gad and C.S. Weil, "Statistics for Toxicologists" in Principles and Methods of Toxicology, A.W. Hayes, Ed., 2nd Edition, P 435-483 Raven Press, New York 1982.

Blood was obtained from the caroid; a drop was placed on glass slides and fixed in Wright's stain. Differential white

50

blood cell counts, platelet counts and hematocrit were obtained for each mouse group sacrificed at the specified times.

The animals were killed by carbon dioxide asphyxiation. After all vital signs had ceased, a midline incision was made from the lower jaw to the inguinal area. Spleen, liver, and kidney were excised and weighed, and representative tissue samples were fixed in 10% buffered formalin, trimmed and sectioned at 6 μ in thickness and stained with hematoxylin and eosin.

The results of these tests, to be published in Arch. Pharm. (Weinhiem) 324, (1991), I. Hall, et al, hereby incorporated herein by reference, showed trimethylamine-carbomethoxyborane to be free of toxicity based on mouse organ weights, hematological parameters, clinical chemistry values, and major tissue morphology. The only deleterious effect noted was the slight reduction of hematocrit at 5 x the therapeutic dose.

All three drugs in 7 days afforded reductions of serum glucose, cholesterol, and triglyceride levels; however, these were not low enough magnitudes of reduction to be life-threatening in any way. All of the animals survived all of the doses with no observable differences in motor or CNS activities. The clinical chemistry and morphological effects observed appeared to be of the type that would be manageable in a clinical situation since they were not severe in nature.

Best Mode For Carrying Out The Invention

In a preferred aspect, the present invention may be practiced as a method of combatting a disease state such as osteoporosis in an animal subject, wherein an effective amount of an organic boron compound of the formula $R_1R_2R_3XBR_4R_5R_6$ is administered to the animal subject, with such administered amount being effective against the disease state, and wherein

the substituents R₁, R₂, R₃, X, R₄, R₅, and R₆ are as defined hereinabove in the discussion of "Class 1" compounds usefully employed in the broad practice of the present invention. A particularly preferred class of compounds for such purpose is the amine carboxyboranes, such as methylamine carboxyboranes. As used in such content, the term "amine-carboxyboranes" is intended to be broadly construed to include carboxyborane adducts of amines per se, as well as corresponding esters and amides. These boron analogs of amino acids are highly effective in anti-osteoporosis treatment.

Industrial Applicability of the Invention

The treatment methodology of the present invention may be usefully employed to combat a variety of disease states such as cystic fibrosis, neonatal hypoxemia, pulmonary hypertension, adult respiratory distress syndrome, psoriasis, spondyloarthritis, rheumatoid arthritis, gout, inflammatory bowel disease, myocardial infarctions, and osteoporosis. The invention also comprehends a method of inhibiting enzyme activity in *in vitro* or *in vivo* systems by administering to such systems an enzyme-inhibiting amount of an organic boron compound, and such method may be usefully employed in various applications for research, diagnostic, and/or treatment purposes. Finally, the invention comprehends a method of reducing hydroxyproline, calcium, and/or inorganic phosphorous in serum and/or urine of an animal subject of an effective amount of an organic boron compound, which likewise may be employed for research, diagnostic, and/or therapeutic purposes.

While the invention has been described herein with reference to illustrative compounds and specific embodiments of the invention, it will be appreciated that numerous variations, modifications, and other embodiments are possible, and

accordingly, all such variations, modifications, and embodiments are to be regarded as being within the spirit and scope of the invention.

THE CLAIMSWhat is Claimed is:

1. A method of combatting a disease state selected from the group consisting of cystic fibrosis, neonatal hypoxemia, pulmonary hypertension, adult respiratory distress syndrome, psoriasis, spondyloarthritis, rheumatoid arthritis, gout, inflammatory bowel disease, myocardial infarctions, and osteoporosis in an animal subject, comprising administering to the animal subject an amount of an organic boron compound which is effective against said disease state.
2. A method according to claim 1, wherein the organic boron compound comprises a Lewis base-boron adduct.
3. A method according to claim 1, wherein the organic boron compound comprises a compound selected from the group consisting of:

(1) organic boron compounds of the formula:



wherein:

X is N or P;

R₁, R₂, R₃ are independently selected from H, C₁-C₂₀ linear or branched alkyl, alkoxy, alkylaryl, aryl, and substituted aryl, or R₁, R₂, and R₃ together with X form a heterocyclic ring structure, with the proviso that when X=N, R₁, R₂ and R₃ are not alkoxy;

R₄ and R₅ are independently selected from H, C₁-C₂₀ linear or branched alkyl, aryl, alkylaryl, and substituted aryl;

⁵⁴
 R_6 is H, C_1 - C_{20} linear or branched alkyl, aryl, alkylaryl, substituted aryl, CN, COOH, COOM, COOR₇, CONHR₇, CONHOH, or COAA, or

R_4 , R_5 , and R_6 together with B form a heterocyclic ring structure;

where:

M is Li, Na, K, or ammonium ion;

R_7 is H, C_1 - C_{10} alkyl, substituted alkyl, aryl, or substituted aryl; and

AA is $NHCH(R_8)COOR_9$ or $NHCH(R_8)CONHR_9$

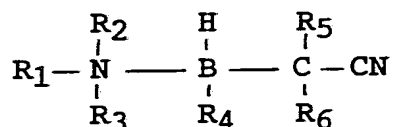
where R_8 is selected from the side chains of common amino acids and R_9 is H, or C_1 - C_5 alkyl.

(2) organic boron compounds of the formula:



wherein: R_1 , R_2 , R_3 , R_4 and X are same as above, and R_5 is CN.

(3) organic boron compounds of the formula:



wherein:

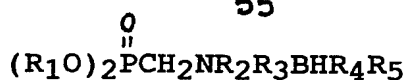
R_1 , R_2 and R_3 are same as in (1);

R_4 is H, C_1 - C_{10} linear or branched alkyl, alkylaryl, or aryl; and

R_5 and R_6 are independently selected from H, C_1 - C_{10} alkyl, alkylaryl, aryl, or substituted aryl;

(4) organic boron compounds of the formula:

55



wherein:

R₁ is C₁-C₁₀ linear or branched alkyl, alkylaryl, or aryl;

R₂, R₃ are independently selected from H, and C₁-C₁₀ linear or branched alkyl;

R₄ is H, C₁-C₁₀ linear or branched alkyl, alkylaryl, or aryl;

R₅ is CN, COOH, CONHR₆, or COOR₆, wherein R₆ is same as R₇ in (1);

(5) organic boron compounds of the formula:



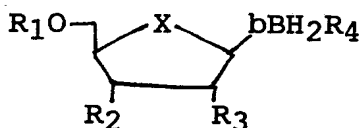
wherein:

X is O or S;

R₁, R₂, R₃ are independently selected from H, C₁-C₁₀ alkyl, alkylaryl, and aryl;

R₄ is NMe₂ or R₅, wherein R₅ is C₁-C₁₀ linear or branched alkyl, alkylaryl, aryl, or substituted aryl;

(6) organic boron compounds of the formula:



wherein:

X is C or O;

R₁ is H or a suitable protecting group;

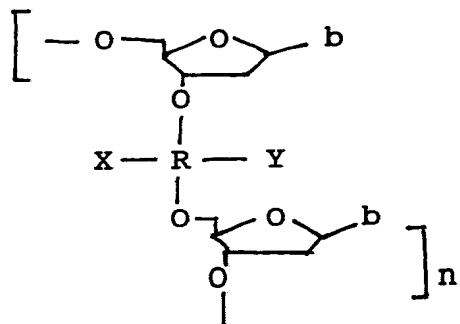
R₂ is H or OH;

R₃ is H or OH;

b represents a nucleoside base;

R₄ is CN, COOH, COOR₅, or CONHR₅, wherein R₅ is H, C₁-C₁₀ alkyl, alkylaryl, aryl, or substituted aryl;

(7) organic boron compounds⁵⁶ of the formula:



wherein:

$n = 1-50$;

b is a nucleoside base;

X is O, or OR, wherein R is CH_3 , CH_2CH_2CN , or CH_2CH_3 ; and

Y is BH_3 , BH_2CN , BH_2COOH , BH_2COOR_1 , or BH_2CONHR ,

wherein R_1 is H, or C_1-C_5 alkyl; and

(8) metal complexes of amine-cyanoboranes, and metal complexes of amine-carboxyboranes.

4. A method according to claim 1, wherein the organic boron compound is selected from the group consisting of organic boron compounds of the formula:



wherein:

X is N or P;

R_1 , R_2 , R_3 are independently selected from H, C_1-C_{20} linear or branched alkyl, alkoxy, alkylaryl, aryl, and substituted aryl, or R_1 , R_2 , and R_3 together with X form a heterocyclic ring structure, with the proviso that when $X=N$, R_1 , R_2 and R_3 are not alkoxy;

57

R₄ and R₅ are independently selected from H, C₁-C₂₀ linear or branched alkyl, aryl, alkylaryl, and substituted aryl;

R₆ is H, C₁-C₂₀ linear or branched alkyl, aryl, alkylaryl, substituted aryl, CN, COOH, COOM, COOR₇, CONHR₇, CONHOH, or COAA, or

R₄, R₅, and R₆ together with B form a heterocyclic ring structure;

where:

M is Li, Na, K, or ammonium ion;

R₇ is H, C₁-C₁₀ alkyl, substituted alkyl, aryl, or substituted aryl; and

AA is NHCH(R₈)COOR₉ or NHCH(R₈)CONHR₉

wherein R₈ is selected from the side chains of common amino acids and R₉ is H, or C₁-C₅ alkyl.

5. A method according to claim 4, wherein X is N.

6. A method according to claim 1, wherein the disease state comprises osteoporosis.

7. A method according to claim 6, wherein the organic boron compound is characterized by (1) in vivo inhibition of proteolytic enzymes involved in mediating osteoporosis, and (2) in vivo inhibition of prostaglandin synthetase activity.

8. A method according to claim 1, wherein the organic boron compound comprises a boron analog of an α -amino acid.

9. A method according to claim 1, wherein the organic boron compound is selected from the group consisting of carboxyborane adducts of Lewis bases, and their corresponding esters and amides.

10. A method according to claim 1, wherein the organic boron compound comprises a carboxyborane adduct of a Lewis base.
11. A method according to claim 1, wherein the animal subject is a mammalian subject.
12. A method according to claim 1, wherein said disease state comprises osteoporosis and said organic boron compound is administered as a preventative for osteoporosis.
13. A method according to claim 1, wherein said disease state comprises osteoporosis and said organic boron compound is administered in treatment of osteoporosis developed in said animal subject.
14. A method of inhibiting enzyme activity of an enzyme selected from the group consisting of prostaglandin cyclooxygenase, 5'-lipxygenase, aryl sulphatase, and collagenase in an *in vitro* or *in vivo* system comprising administering to the system an enzyme-inhibitingly effective amount of an organic boron compound which is effective against said enzyme(s).
15. A method according to claim 14, wherein the organic boron compound comprises a Lewis base-boron adduct.
16. A method according to claim 14, wherein the organic boron compound is selected from the group consisting of:

(1) organic boron compounds of the formula:



wherein:

X is N or P;

⁵⁹
 R_1 , R_2 , R_3 are independently selected from H, C_1 - C_{20} linear or branched alkyl, alkoxy, alkylaryl, aryl, and substituted aryl, or R_1 , R_2 , and R_3 together with X form a heterocyclic ring structure, with the proviso that when $X=N$, R_1 , R_2 and R_3 are not alkoxy;

R_4 and R_5 are independently selected from H, C_1 - C_{20} linear or branched alkyl, aryl, alkylaryl, and substituted aryl;

R_6 is H, C_1 - C_{20} linear or branched alkyl, aryl, alkylaryl, substituted aryl, CN, COOH, COOM, COOR₇, CONHR₇, CONHOH, or COAA, or

R_4 , R_5 , and R_6 together with B form a heterocyclic ring structure;

where:

M is Li, Na, K, or ammonium ion;

R_7 is H, C_1 - C_{10} alkyl, substituted alkyl, aryl, or substituted aryl; and

AA is $NHCH(R_8)COOR_9$ or $NHCH(R_8)CONHR_9$

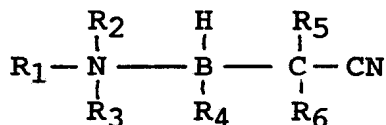
where R_8 is selected from the side chains of common amino acids and R_9 is H, or C_1 - C_5 alkyl.

(2) organic boron compounds of the formula:



wherein: R_1 , R_2 , R_3 , R_4 and X are same as above, and R_5 is CN.

(3) organic boron compounds of the formula:



60

wherein:

R_1 , R_2 and R_3 are same as in (1);

R_4 is H, C_1 - C_{10} linear or branched alkyl, alkylaryl, or aryl; and

R_5 and R_6 are independently selected from H, C_1 - C_{10} alkyl, alkylaryl, aryl, or substituted aryl;

(4) organic boron compounds of the formula:



wherein:

R_1 is C_1 - C_{10} linear or branched alkyl, alkylaryl, or aryl;

R_2 , R_3 are independently selected from H, and C_1 - C_{10} linear or branched alkyl;

R_4 is H, C_1 - C_{10} linear or branched alkyl, alkylaryl, or aryl;

R_5 is CN, COOH, CONHR₆, or COOR₆, wherein R_6 is same as R_7 in (1);

(5) organic boron compounds of the formula:



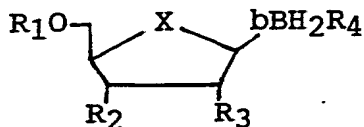
wherein:

X is O or S;

R_1 , R_2 , R_3 are independently selected from H, C_1 - C_{10} alkyl, alkylaryl, and aryl;

R_4 is NMe₂ or R₅, wherein R₅ is C_1 - C_{10} linear or branched alkyl, alkylaryl, aryl, or substituted aryl;

(6) organic boron compounds of the formula:



61

wherein:

X is C or O;

R₁ is H or a suitable protecting group;

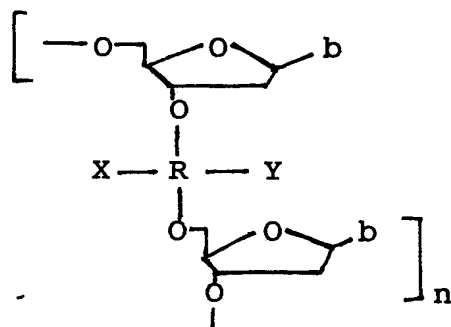
R₂ is H or OH;

R₃ is H or OH;

b represents a nucleoside base;

R₄ is CN, COOH, COOR₅, or CONHR₅, wherein R₅ is H, C₁-C₁₀ alkyl, alkylaryl, aryl, or substituted aryl;

(7) organic boron compounds of the formula:



wherein:

n = 1-50;

b is a nucleoside base;

X is O, or OR, wherein R is CH₃, CH₂CH₂CN, or CH₂CH₃; and

Y is BH₃, BH₂CN, BH₂COOH, BH₂COOR₁, or BH₂CONHR,

wherein R₁ is H, or C₁-C₅ alkyl; and

(8) metal complexes of amine-cyanoboranes, and metal complexes of amine-carboxyboranes.

17. A method according to claim 14, wherein the organic boron compound is a Lewis base-carboxyborane, or its corresponding ester or amide.

18. A method according to claim 14, wherein the organic boron compound comprises a Lewis base-carboxyborane.

19. A method according to claim ⁶²14, wherein said enzymes comprise prostaglandin cyclooxygenase and 5'-lipoxygenase.

20. A method of reducing hydroxyproline, calcium, and/or inorganic phosphorous in serum and/or urine of an animal subject, comprising administering to the animal subject an effective amount of an organic boron compound which is reducingly effective therefor.

AMENDED CLAIMS

[received by the International Bureau on 28 January 1993 (28.01.93);
original claims 1, 14 and 20 amended; remaining claims
unchanged (9 pages)]

1. A method of combatting a disease state selected from the group consisting of cystic fibrosis, neonatal hypoxemia, pulmonary hypertension, adult respiratory distress syndrome, psoriasis, spondyloarthritis, rheumatoid arthritis, gout, inflammatory bowel disease, myocardial infarctions, and osteoporosis in an animal subject, comprising administering to the animal subject an amount of an organic boron compound which (i) is effective against said disease state, and (ii) does not cause a statistically significant increase in hydroxylated steroids selected from the group consisting of 17- β -estradiol and testosterone.
2. A method according to claim 1, wherein the organic boron compound comprises a Lewis base-boron adduct.
3. A method according to claim 1, wherein the organic boron compound comprises a compound selected from the group consisting of:

(1) organic boron compounds of the formula:



wherein:

X is N or P;

R_1 , R_2 , R_3 are independently selected from H, C_1 - C_{20} linear or branched alkyl, alkoxy, alkylaryl, aryl, and substituted aryl, or R_1 , R_2 , and R_3 together with X form a heterocyclic ring structure, with the proviso that when $X=N$, R_1 , R_2 and R_3 are not alkoxy;

R_4 and R_5 are independently selected from H, C_1 - C_{20} linear or branched alkyl, aryl, alkylaryl, and substituted aryl;

R_6 is H, C_1 - C_{20} linear or branched alkyl, aryl, alkylaryl, substituted aryl, CN, COOH, COOM, COOR₇, CONHR₇, CONHOH, or COAA, or

R_4 , R_5 , and R_6 together with B form a heterocyclic ring structure;

where:

M is Li, Na, K, or ammonium ion;

R_7 is H, C_1 - C_{10} alkyl, substituted alkyl, aryl, or substituted aryl; and

AA is $NHCH(R_8)COOR_9$ or $NHCH(R_8)CONHR_9$

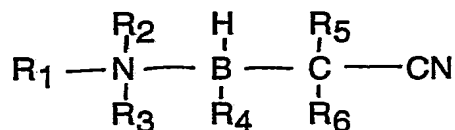
where R_8 is selected from the side chains of common amino acids and R_9 is H, or C_1 - C_5 alkyl.

(2) organic boron compounds of the formula:



wherein: R_1 , R_2 , R_3 , R_4 and X are same as above, and R_5 is CN.

(3) organic boron compounds of the formula:



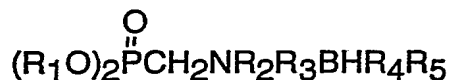
wherein:

R_1 , R_2 and R_3 are same as in (1);

R_4 is H, C_1 - C_{10} linear or branched alkyl, alkylaryl, or aryl; and

R_5 and R_6 are independently selected from H, C_1 - C_{10} alkyl, alkylaryl, aryl, or substituted aryl;

(4) organic boron compounds of the formula:



wherein:

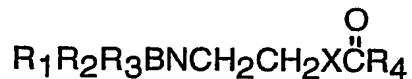
R_1 is C_1 - C_{10} linear or branched alkyl, alkylaryl, or aryl;

R_2 , R_3 are independently selected from H, and C_1 - C_{10} linear or branched alkyl;

R_4 is H, C_1 - C_{10} linear or branched alkyl, alkylaryl, or aryl;

R_5 is CN, COOH, CONHR₆, or COOR₆, wherein R_6 is same as R_7 in (1);

(5) organic boron compounds of the formula:



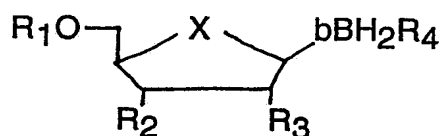
wherein:

X is O or S;

R_1 , R_2 , R_3 are independently selected from H, C₁-C₁₀ alkyl, alkylaryl, and aryl;

R_4 is NMe₂ or R_5 , wherein R_5 is C₁-C₁₀ linear or branched alkyl, alkylaryl, aryl, or substituted aryl;

(6) organic boron compounds of the formula:



wherein:

X is C or O;

R_1 is H or a suitable protecting group;

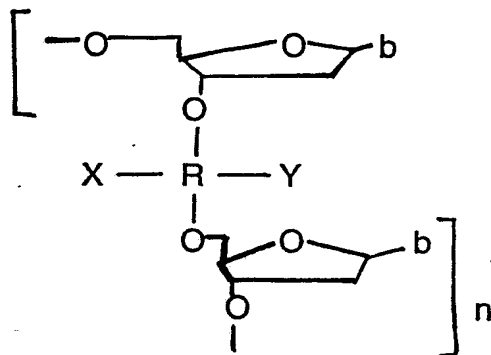
R_2 is H or OH;

R_3 is H or OH;

b represents a nucleoside base;

R_4 is CN, COOH, COOR₅, or CONHR₅, wherein R_5 is H, C₁-C₁₀ alkyl, alkylaryl, aryl, or substituted aryl;

(7) organic boron compounds of the formula:



wherein:

$n = 1-50$;

b is a nucleoside base;

X is O, or OR, wherein R is CH_3 , $\text{CH}_2\text{CH}_2\text{CN}$, or CH_2CH_3 ; and

Y is BH_3 , BH_2CN , BH_2COOH , BH_2COOR_1 , or BH_2CONHR ,

wherein R_1 is H, or $\text{C}_1\text{-C}_5$ alkyl; and

(8) metal complexes of amine-cyanoboranes, and metal complexes of amine-carboxyboranes.

4. A method according to claim 1, wherein the organic boron compound is selected from the group consisting of organic boron compounds of the formula:



wherein:

X is N or P;

R_1 , R_2 , R_3 are independently selected from H, $\text{C}_1\text{-C}_{20}$ linear or branched alkyl, alkoxy, alkylaryl, aryl, and substituted aryl, or R_1 , R_2 , and R_3 together with X form a heterocyclic ring structure, with the proviso that when $\text{X}=\text{N}$, R_1 , R_2 and R_3 are not alkoxy;

R_4 and R_5 are independently selected from H, $\text{C}_1\text{-C}_{20}$ linear or branched alkyl, aryl, alkylaryl, and substituted aryl;

R_6 is H, $\text{C}_1\text{-C}_{20}$ linear or branched alkyl, aryl, alkylaryl, substituted aryl, CN, COOH, COOM, COOR_7 , CONHR_7 , CONHOH , or COAA, or

R_4 , R_5 , and R_6 together with B form a heterocyclic ring structure;

where:

M is Li, Na, K, or ammonium ion;

R_7 is H, $\text{C}_1\text{-C}_{10}$ alkyl, substituted alkyl, aryl, or substituted aryl; and

AA is $\text{NHCH}(\text{R}_8)\text{COOR}_9$ or $\text{NHCH}(\text{R}_8)\text{CONHR}_9$

wherein R₈ is selected from the side chains of common amino acids and R₉ is H, or C₁-C₅ alkyl.

5. A method according to claim 4, wherein X is N.
6. A method according to claim 1, wherein the disease state comprises osteoporosis.
7. A method according to claim 6, wherein the organic boron compound is characterized by (1) in vivo inhibition of proteolytic enzymes involved in mediating osteoporosis, and (2) in vivo inhibition of prostaglandin synthetase activity.
8. A method according to claim 1, wherein the organic boron compound comprises a boron analog of an α -amino acid.
9. A method according to claim 1, wherein the organic boron compound is selected from the group consisting of carboxyborane adducts of Lewis bases, and their corresponding esters and amides.
10. A method according to claim 1, wherein the organic boron compound comprises a carboxyborane adduct of a Lewis base.
11. A method according to claim 1, wherein the animal subject is a mammalian subject.
12. A method according to claim 1, wherein said disease state comprises osteoporosis and said organic boron compound is administered as a preventative for osteoporosis.
13. A method according to claim 1, wherein said disease state comprises osteoporosis and said organic boron compound is administered in treatment of osteoporosis developed in said animal subject.
14. A method of inhibiting enzyme activity of an enzyme selected from the group consisting of prostaglandin cyclooxygenase, 5'-lipoxygenase, aryl sulphatase, and collagenase in an *in vitro* or *in vivo* system comprising administering to the system an

enzyme-inhibitingly effective amount of an organic boron compound which is effective against said enzyme(s) and which does not cause a statistically significant increase in hydroxylated steroids selected from the group consisting of 17- β -estradiol and testosterone.

15. A method according to claim 14, wherein the organic boron compound comprises a Lewis base-boron adduct.

16. A method according to claim 14, wherein the organic boron compound is selected from the group consisting of:

(1) organic boron compounds of the formula:



wherein:

X is N or P;

R_1 , R_2 , R_3 are independently selected from H, C_1 - C_{20} linear or branched alkyl, alkoxy, alkylaryl, aryl, and substituted aryl, or R_1 , R_2 , and R_3 together with X form a heterocyclic ring structure, with the proviso that when $X=N$, R_1 , R_2 and R_3 are not alkoxy;

R_4 and R_5 are independently selected from H, C_1 - C_{20} linear or branched alkyl, aryl, alkylaryl, and substituted aryl;

R_6 is H, C_1 - C_{20} linear or branched alkyl, aryl, alkylaryl, substituted aryl, CN, COOH, COOM, COOR₇, CONHR₇, CONHOH, or COAA, or

R_4 , R_5 , and R_6 together with B form a heterocyclic ring structure;

where:

M is Li, Na, K, or ammonium ion;

R_7 is H, C_1 - C_{10} alkyl, substituted alkyl, aryl, or substituted aryl; and

AA is $\text{NHCH}(\text{R}_8)\text{COOR}_9$ or $\text{NHCH}(\text{R}_8)\text{CONHR}_9$

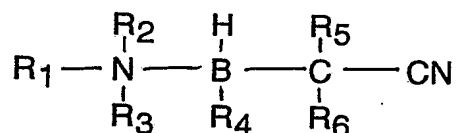
where R_8 is selected from the side chains of common amino acids and R_9 is H, or C₁-C₅ alkyl.

(2) organic boron compounds of the formula:



wherein: R_1 , R_2 , R_3 , R_4 and X are same as above, and R_5 is CN.

(3) organic boron compounds of the formula:



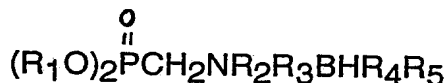
wherein:

R_1 , R_2 and R_3 are same as in (1);

R_4 is H, C₁-C₁₀ linear or branched alkyl, alkylaryl, or aryl; and

R_5 and R_6 are independently selected from H, C₁-C₁₀ alkyl, alkylaryl, aryl, or substituted aryl;

(4) organic boron compounds of the formula:



wherein:

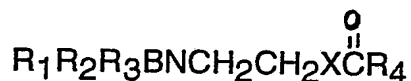
R_1 is C₁-C₁₀ linear or branched alkyl, alkylaryl, or aryl;

R_2 , R_3 are independently selected from H, and C₁-C₁₀ linear or branched alkyl;

R_4 is H, C₁-C₁₀ linear or branched alkyl, alkylaryl, or aryl;

R_5 is CN, COOH, CONHR₆, or COOR₆, wherein R_6 is same as R_7 in (1);

(5) organic boron compounds of the formula:



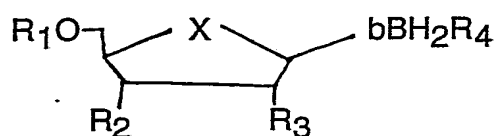
wherein:

X is O or S;

R₁, R₂, R₃ are independently selected from H, C₁-C₁₀ alkyl, alkylaryl, and aryl;

R₄ is NMe₂ or R₅, wherein R₅ is C₁-C₁₀ linear or branched alkyl, alkylaryl, aryl, or substituted aryl;

(6) organic boron compounds of the formula:



wherein:

X is C or O;

R₁ is H or a suitable protecting group;

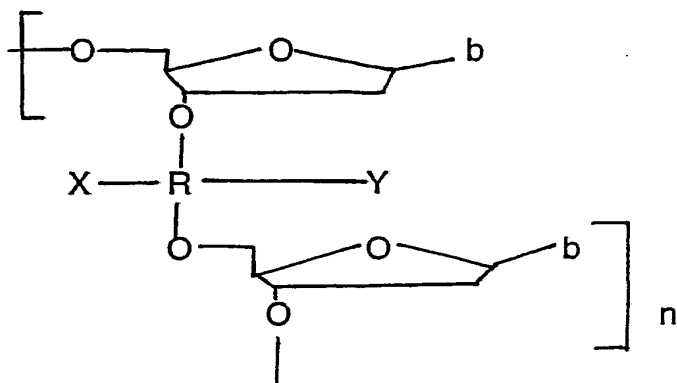
R₂ is H or OH;

R₃ is H or OH;

b represents a nucleoside base;

R₄ is CN, COOH, COOR₅, or CONHR₅, wherein R₅ is H, C₁-C₁₀ alkyl, alkylaryl, aryl, or substituted aryl;

(7) organic boron compounds of the formula:



wherein:

$n = 1-50$;

b is a nucleoside base;

X is O, or OR, wherein R is CH_3 , $\text{CH}_2\text{CH}_2\text{CN}$, or CH_2CH_3 ; and

Y is BH_3 , BH_2CN , BH_2COOH , BH_2COOR_1 , or BH_2CONHR ,

wherein R_1 is H, or $\text{C}_1\text{-C}_5$ alkyl; and

(8) metal complexes of amine-cyanoboranes, and metal complexes of amine-carboxyboranes.

17. A method according to claim 14, wherein the organic boron compound is a Lewis base-carboxyborane, or its corresponding ester or amide.

18. A method according to claim 14, wherein the organic boron compound comprises a Lewis base-carboxyborane.

19. A method according to claim 14, wherein said enzymes comprise prostaglandin cyclooxygenase and 5' lipoxygenase.

20. A method of reducing hydroxyproline, calcium, and/or inorganic phosphorous in serum and/or urine of an animal subject, comprising administering to the animal subject an effective amount of an organic boron compound which is reducingly effective therefor and does not cause a statistically significant increase in hydroxylated steroids selected from the group consisting of 17- β -estradiol and testosterone.

STATEMENT UNDER ARTICLE 19

Enclosed are new substitute pages 53-62 for replacement of pages 53-63 of the originally filed international patent application.

The new pages introduce revised claims 1, 14 and 20, wherein each has been amended to recite that the amount of organic boron compound which is effective against the identified disease state "does not cause a statistically significant increase in hydroxylated steroids selected from the group consisting of 17- β -estradiol and testosterone."

INTERNATIONAL SEARCH REPORT

PCT/US92/07717

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :A61K 33/22 , 31/69

US CL :424/657,658,659,660,514/64

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. :

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Please See Extra Sheet.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A, 4,849,220 (NIELSEN ET AL) 18 JULY 1989 See abstract and column 2, lines 10-15	1-20

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be part of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

02 DECEMBER 1992

Date of mailing of the international search report

8 DEC 1992

Name and mailing address of the ISA/
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Authorized officer

T.J. CRIARES

Facsimile No. NOT APPLICABLE

Telephone No. (703) 308-1235

B. FIELDS SEARCHED

Electronic data bases consulted (Name of data base and where practicable terms used):

APS: 1) Organo Boron Compounds (P) Osteoporosis

2) Compound $\text{RNH}_2\text{BH}_2\text{-COOH}$

or

$\text{RNH}_2\text{BH}_2\text{CH}_2\text{OH}$ (P) Osteoporosis

R=alkyl 1-6c's or heterocyclic